# MANALYTICS, INC.

August 22, 1986

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Gentlemen:

Over the past six weeks, your organizations have read and critiqued Manalytics' draft report on the "San Francisco Pilots' Manpower Study." Both organizations have submitted extensive comments. We have taken those comments seriously in the subsequent revision of the report. Enclosed herewith, then, is the final report ready for your submission to the Board of Pilot Commissioners.

You will note that, in keeping with the major criticisms of the draft report, we have:

- Tightened the Executive Summary considerably, with a consequent reduction from 17 pages to eight pages;
- Deleted conclusory remarks that could be construed as recommendations, particularly those relating to the rotation schedule and Accumulated Time Off; and
- Clarified assumptions made during the development of the model (particularly regarding peak traffic periods and the peak demand multiplier).

The inputs from the industry and the pilots have led to a far better product than would otherwise have been the case, in general and in specifics. Although at times the comments of the industry and of the pilots were mutually exclusive, we have generally been able to affect what we believe are acceptable accommodations. Also, we believe that both sides will find that the model itself will further alleviate some of the concerns that precipitated your comments.

We look forward to presenting our findings to the Commission and assisting in the operation of the model.

Sincerely yours,

Robert L. Hanelt
Manager-Maritime

RLH:rbh
enclosure

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MANALYTICS, INC.

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# SAN FRANCISCO PILOTS MANPOWER STUDY

a report to

PACIFIC MERCHANT SHIPPING ASSOCIATION
SAN FRANCISCO BAR PILOTS

August 22, 1986

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# I. EXECUTIVE SUMMARY

## SCOPE

Recent legislation (AB1768) ammended the California State Harbors and Navigation Code to amalgamate previously unassociated San Francisco bar and bay pilots into a unified organization. The new organization, collectively known as the San Francisco Bar Pilots, is the single organization that provides pilotage for vessels operating over the San Francisco bar and in San Francisco, San Pablo and Suisun Bays. The ports of Sacramento and Stockton retained the right to license their own pilots, but these pilots are also members of the San Francisco Bar Pilots.

AB1768 also created an expanded Board of San Francisco Bay Pilot Commissioners. In accord with grandfather rights extended to all active pilots by AB1768, the new Board licensed 30 ex-"bar" and 26 ex-"inland" pilots to staff the new, unified organization. The Board (usually referred to as the Commission) has authority to modify the number of licensed pilots as the originally licensed pilots retire or otherwise leave the San Francisco Bar Pilots and as the ship traffic patterns change.

The Commission has not appointed replacements for two pilots who retired since the amalgamation (although it has authorized the hiring of four trainee pilots in anticipation of future retirements), since it is unsure of the number of pilots that are required. To answer this question, the industry, represented by the Pacific Merchant Shipping Association (PMSA), and the San Francisco Bar Pilots jointly commissioned this study to evaluate the factors that determine the number of pilots required and to develop a computerized model that will simulate the interaction of these factors. The model will then be used to determine the number of pilots required to safely and efficiently perform pilotage on the bar and bays of San Francisco under varying pilotage scenarios.

The primary objective of this study was to develop a computer model that would determine the minimum number of pilots required to perform safe and efficient pilotage under various scenarios of ship traffic patterns and peak ship arrivals/departures. This objective took the study beyond the realm of previous studies--a realm concerned only with the number of hours a pilot should work each year--to a more complex analysis of pilot work rules and practices, and the impact of these rules and practices on pilot stress and workload. The Commission does not want to forecast the number of pilots required simply on an assumption that a pilot ought to work a prescribed number of hours each year. Rather, it wants to include the inter-relationships of the work environment, of the work cycle, and of safe and efficient pilotage on the supply side; and of ship traffic patterns and ship arrival and departure bunching on the demand side. With a computer model to show the impact of these interrelationships on the required number of pilots, the Commission will be able to discharge its responsibilities under a range of circumstances.

The computer model can best be described as a "what-if" model that evaluates the impact of changing one or more specific variables on the required number of pilots. For example, the Commission might ask "what if the minimum number of hours between assignments were changed from 12 hours to 14 hours? The "what-if" model would then calculate the required number of pilots based on the complex interrelationships of work rules and practices and the peak levels of ship arrivals and departures at bay and river terminals.

APPROACH

Much of the effort in developing the what-if model involved the evaluation of the impact of current work rules and practices. It was apparent that only some of them had an impact on the number of pilots--but which ones and with what inter-relationships? Further, if certain rules or practices were changed, what would be the impact on the pilots themselves? Rules and practices implemented over 150 years of pilotage on San Francisco Bay reflect the pilots' understanding of the demands placed on them by their workload and by the stressful nature of their job. We needed to understand the basis for the key rules and practices that influence the number of pilots required and the boundaries of reasonable change. Finally, we had to describe traffic volumes and patterns and peaks the variations in them so the model could account for ship arrivals and departures (and for potential ship delays) in deriving the demand for pilots.

The study had three major components: 1) Human Factors Analysis, which evaluated the pilots' perception of job stress and satisfaction and the impact of changes in work design on these qualities of the pilot job; 2) Pilot Workload Analysis, which evaluated the pilots' current workload, including the impact of work rules and practices on the workload as well as fluctuating and peak traffic volumes; and 3) a "what-if" computer model to generate the required number of pilots under different combinations of work rules and practices and traffic patterns and volumes. The study team that undertook these analyses was comprised of members of Manalytics' staff and Dr. Donald L. Tasto, a behavioral psychologist who specializes in the health consequences of stress and in occupational stress management.

Human Factors

The human factors analysis was incorporated into the study to determine, broadly and generally, whether the pilots are exposed to stressful jobs, and, if they are, what job factors might contribute to the stress. The impact of varying work practices on these stress factors could then be analyzed, leading to the development of reasonable and appropriate variations in work rules and practices as input to the computer model.

The assessment of factors such as stress, satisfaction/dissatisfaction, and reactions to stress requires quantification of perceptions of, and reactions to, one's environment. For this quantification, we utilized existing tests with population norms, against which the pilots could be compared. At the same time, we developed our own questions that were highly specific to the needs and concerns of the pilots.

In developing our own questions, we interviewed three ex-"bar" pilots and three ex-"inland" pilots to learn of the pilots' particular concerns in terms of job stress and job satisfaction. Based on the interview results, we then developed a questionnaire to be answered by all pilots. Specifically, we were looking for pilot attitudes toward work practices that impact on the pilots' ability to perform safe and efficient pilotage and, ultimately, on the number of pilots required. The minimum rest period between assignments (MRP) and the work rotation schedule (Accumulated Time Off or ATO) were particular targets of our inquiry.

Summary - human factors

In summary, the pilots like the nature of their work and are highly satisfied with the fact that they are pilots. Their job, nevertheless, has a number of factors that are stressful and a number of factors that are dissatisfying. The stress factors relate to the danger of the work, the costly consequences of making an error, decisions being made about them outside of their control, and disruption to the sleep/wake pattern. Slightly more than half of the pilots believe there should be an increase in compensation, and slightly less than half feel there should be more time between assignments. The most prominent dissatisfaction has to do with the quality of sleep: the pilots tend to feel tired, fatigued, anxious and tense.

Summary - pilot workload

In summary, pilots work approximately 12-hour shifts with an average rest period between assignments of nearly 21 hours. During periods of peak demand, however, the rest period drops to eight hours (and lower). Thus, peak vessel activity has a significant impact on the pilot workload and, consequently, the manning levels.

The three major determinants of the required number of pilots are the length of the minimum rest period, the ATO rotation schedule, and the peak traffic volumes. To a much lesser extent, allowance for sick leave, time for pilot administration and the impact of Rule 51, which allows for extra time off between assignments following a river move, also impact on the required number of pilots. Any computer model, to be used to determine the required manning level for pilots, should account for these factors. It should allow the user to vary the values of all these factors to determine the impact of changing any one of them on the required number of pilots.

"What-If" Model

A simple model, based on the average time to complete a specific pilotage, the average time between assignments, and the ATO rotation schedule could calculate the number of pilots required to pilot the vessels, after allowing for sick leave and for the performance of administrative duties. But the answer would not be accurate, since this simple model would not take into account one of the three major determinants affecting the number of pilots: the peak demand for pilots due to day-to-day and month-to-month fluctuations in traffic volume. The "what-if" model does take these fluctuations into account through the utilization of a peak multiplier and a seasonal peaking factor.

In our analysis of the fluctuation in demand for pilots we observed, for example, that the average number of arrivals at the San Francisco Pilot Station was 9.33 vessels per day. But the actual number of arrivals varied from two ships to 20 ships. The highest peak was more than twice the average number of arrivals. The second highest peak (14 arrivals) was 50 percent higher than the average. Our analysis showed that, had the pilots staffed to accommodate the average number of arrivals at least ten ships would have been delayed at least one day each during the highest peak day--and following two days--before equilibrium between the number of arrivals and the supply of pilots had been restored. Of course, this was the worst case we observed during the survey, and other demands for departure, bay and river pilotage (as well as administrative demands on pilots) tend to smooth the peaks and valleys of demand, but a significant fluctuation in demand for pilots does exist. We have included a peak demand multiplier of 2.25 to account for the intermittent day-to-day peaks that randomly occurred during the sample period; the model can include any value for the multiplier. In addition, the user is required to enter a seasonal factor to account for the historical fluctuation in month-to-month traffic volumes (up to 11 percent between February and June).

We evaluated how the pilots currently accommodate such peaks in demand. During the sample period, the number of pilots engaged in activities relating to pilotage or necessary administration on any one day averaged 13 pilots (not including the Port Agent). But the actual number of pilots so engaged on any one day varied from six to 24 pilots. During the survey period, pilots were able to accommodate the peak days' demand for pilots by short-turning (that is, reducing the average rest period between assignments). On several occasions, pilots approached or had less than the current minimum rest period of eight hours.

To accommodate the fluctuations in demand, we developed equations in addition to those that calculate simply the required number of pilots according to average traffic (assuming evenly distributed arrivals). These equations were developed following detailed analysis of six peak days of the survey period. From this analysis, we developed the average number of pilots that would have been required depending on variations in the minimum rest period between assignments.

The average rest period during the survey was nearly 21 hours. Current pilot practice sets the minimum rest period at eight hours. Only during periods at peak demand does the average rest period approach the minimum rest period. Intuitively, it was apparent that, as the MRP is increased, more pilots would be required during peak periods, since they could not return from time off as soon to accept another assignment. But how many additional pilots were required with each incremental hourly increase of the MRP? We developed these factors for MRP values from eight to 18 hours and incorporated them in the "what-if" model.

The "what-if" model is a straight-forward, yet powerful, computer program that has long-term applicability. Its sophisitication is in its design, not in its use. It requires no modification to accommodate future changes in traffic volume or in pilot work rules or practices; only its input parameters need be changed.

One of the basic assumptions that we have made in our analysis is that the peaking phenomenon that was experienced during the study period represents the peaking phenomenon for the entire year, and, thus, that the impact of the work rules during the study period is representative of the impact of the work rules throughout the entire year. If, for example, the ratio of the peak demand to average demand for pilot service was 2.25 during the study period, we assume that the ratio will be 2.25 throughout a complete year, particularly that portion where the seasonal number of arrivals and sailings is at its greatest. Additionally, we assume that individual work rules will not have an impact on the number of pilots required unless those work rules had an impact during the study period.

The peak multiplier of 2.25, is close to the average multiplier experienced during the study period (which was 2.24). Although we are convinced it is the appropriate multiplier for the study period, we are not convinced that it is the appropriate multiplier for the future. It is possible that the pilots will observe higher multipliers in the immediate future. There is some evidence that the minimum rest period was reduced to seven hours for several days early in the month of April. If so, the peak demand may have been greater than 2.25 times the average demand. Conversely, we believe the multiplier will decrease if the amount of traffic entering and leaving the Bay increases. In the extreme case, the Bar Channel will serve as a metering device and limit the number of vessels that can enter the Bay or leave the Bay to, say, one vessel every 15 minutes. Once the traffic reaches that level (an arrival once every 15 minutes), there will be no multiplier, as there will be a uniform flow throughout the day, throughout the month, and throughout the year.

Because of the importance of the peak multiplier to the generation of pilot demand by the model, the pilots and the industry should establish a method to derive the appropriate value. Statistics should be incorporated in the pilots' day-to-day data collection and invoicing system and periodically reviewed to determine if the peak multiplier in the model should be changed. The two-month sample period in our study is too short; a full year would be best.

## II. HUMAN FACTORS ANALYSIS

### Methodology

The objective of the human factors analysis was to determine, broadly, whether the pilots are exposed to stressful jobs, and, if they are, what factors on the job might contribute to the stress.

First, we reviewed important recent literature on pilotage, including particularly: "A Human Factors Study of Marine Pilotage" (Shipley, 1978); "Port Phillip Sea Pilots" (Berger, 1983, 1984); and "A Study of the Work of Dutch Government Maritime Pilots and Its Influence on the Well Being of the Pilot and on His Family" (Department of Occupational Psychology, University of Groningen, 1982). We also reviewed studies relating to issues of occupational stress, job satisfaction/dissatisfaction, and the effects of disruption to the sleep/wake cycle generally (Appendix A).

Assessment of factors such as stress, satisfaction/dissatisfaction, and reactions to stress necessitate quantification of perceptions of, and reactions to, one's environment. We utilized existing tests with population norms against which the San Francisco Bar Pilots could be compared. At the same time, we developed some of our own questions that were highly specific to the needs and concerns of the pilots.

Because early discussions indicated that there could be significant differences in attitudes and concerns regarding job stress and job satisfaction between the ex-bar pilots and the ex-inland pilots, we randomly chose three ex-bar pilots and three ex-inland pilots for interviews to help identify the nature of the job and the concerns that the pilots had. We decided to conduct a minimum of six interviews, but we would interview as many pilots as was necessary for a full insight. As it turned out, we stopped at six because there was a high degree of overlap in terms of the description of the job, its responsibilities, and the concerns of the pilots.

Based on information obtained from detailed interviews with these six pilots, coupled with a review of existing literature on pilotage, we developed four pilot-specific sections of a six section questionnaire: namely, Potential Stress Factors, Satisfaction/Dissatisfaction, Reactions to the Job, and Open Ended Questions. All six sections of the questionnaire are described below and the questionnaire itself, along with Dr. Tasto's cover letter and instructions to the pilots, is contained in Appendix B.

1) Work Environment. This section, although not specific to the piloting vocation, was included in the questionnaire as the most relevant standardized published test related to one's working environment. The norms are presented in standardized scores, which means that, by definition, the average rating equals 50 and the standard deviation (a measure of scatter or variability about the average) equals 10.

The advantage of such a test is that it allows us to compare the scores of the pilots with standardized norms on eight different scales. The disadvantage of such a test is that not all of the items are specifically relevant to a particular job, or some items are too general and, as such, can miss specific issues of a particular job. This test was included for purposes of comparison, but with the understanding that some of the scales may not be targeted precisely to the pilot population. The limitation was considered when we interpreted the data.

2) Job Stress. This section was included because its series of 15 items related to one's job have been used in many research studies. These questions have been developed and refined over time, and people in most occupations are able to rate them in a meaningful way. This test, for example, was used in Dr. Meyer Friedman's 5-year Recurrent Coronary Prevention Project, which was conducted in the San Francisco Bay Area. It has also been used in studies at SRI International, University of North Carolina, and a variety of other places.

Each of the items is rated on a 5 point scale. While there are no published norms on this test, Dr. Tasto has used these items on hundreds of people and has developed norms of his own over the years. In addition, it is possible to assess which items show higher than normal ratings and which items show lower ratings to help identify some of the areas where there are problems for the pilots and some of the areas where there are not problems for the pilots.

3) Potential Stress Factors. This section consisted of 20 items that were identified from the interviews and from previous literature as potentially stressful to pilots. The format was setup for each item to be rated on a 10-point scale, ranging from "non-stressful" (one point) to "extremely stressful" (ten points).

4) Satisfaction/Dissatisfaction. Satisfaction or dissatisfaction with one's job and its various components is something that can be independent from job stress. That is, a person may feel under stress, but may also like the work; a person may feel under stress and dislike the work; a person may feel that the job is non-stressful and dislike the work; or a person may feel the job is non-stressful and like the work. A total of 15 items were identified relating to the dimension of satisfaction/dissatisfaction. This format was also set up so that each item could be rated on a ten-point scale, with "extremely dissatisfied" rated as one point and "extremely satisfied" rated as ten points.

5) Reactions to the Job. It is one thing to perceive a job a certain way, but how a person reacts to the job, however, can vary considerably from one person to another even if the perception is shared. The pilots that were interviewed, as well as the previous studies in the field, pointed to a number of reactions that can occur. Twenty such reactions were identified and set up on a 10 point scale, with "no problem" at one point, and "severe problem" at ten points.

6) Open Ended Questions. Some questions were not amenable to rating on a ten-point scale. We asked the pilots to rate several items

"yes" or "no" and left them space to elaborate. There was also space at the bottom of the page for any further comments they cared to make.

An issue was raised early in the study regarding inclusion in the questionnaire of the various things pilots do or can do to reduce stress. Consideration of stress-relieving actions is typically not done in scientific approaches to the assessment of occupational stress; rather, it is usually associated with stress management programs, which are designed to teach individuals more effective ways to cope with stress. Since the purpose of this study was to evaluate the nature of the job, rather than to teach people methods for reducing their stress, we did not make a formal attempt to assess what pilots may be doing to reduce their stress. The degree to which pilots may be doing things to reduce their stress, and the degree to which such methods are effective, would be reflected in the overall ratings of stress. For example, there was an item asking individuals to rate how stressful is the anticipatory period between a call from the dispatcher and the actual commencement of work. If a person were exercising, reading, playing golf, doing relaxation exercises, or engaging in some form of effective stress management, this time period would be rated less stressful, reflecting the effects of the stress reducing strategies. Likewise, if time spent on the pilot boat were used productively to reduce stress, then the rating on that item would be low. Conversely, if the pilots were not engaging in stress reducing methods that are effective at those times, higher stress ratings would occur.

Questionnaire Responses

The six sections of the questionnaire were packaged and sent to each of the pilots, with an explanation as to the limitations of the Work Environment Scale and of the Job Stress Questionnaire. The pilots were told that it was most important that they not collaborate with each other, but rather provide their own answers representing their true feelings, attitudes, and opinions. They were also asked not to exaggerate responses in one direction or another, but rather to be as honest and straight forward as possible. Finally, they were told that all responses would be held in the strictest of confidence and that all information would be presented in statistical, summary, or conclusion form without reference to any specific individual's responses. They were asked to mail back their completed questionnaires within 24 hours of receiving them.

The questionnaire was sent to the 54 pilots; 53 pilots, including the Port Agent, filled out the questionnaire and sent it back. Three of the 53 respondents did not complete the Work Environment Scale. Since the Port Agent's job is significantly different from that of the rest of the pilots, his responses were not included in the study. Thus, there were 49 analyzable respondents to the Work Environment Scale, 52 to the other sections of the questionnaire. We regard this as a very good response, and it provided us with a statistically valid sample.

Data were entered into a computer, and the means and standard deviations were calculated for responses on all items except the Work Environment Scale. On this scale, means and standard deviations were calculated for the subscales in standard score form. All means and standard deviations were carried out to a third decimal point and rounded off to two decimal places for purposes of presentation. Since we are concerned with the statistical population of San Francisco Bar Pilots itself, rather than considering this group to be representative of a larger group, the formula for population standard deviations, rather than for sample standard deviations, was used.

Work Environment Scale

Table 1 presents the results of the Work Environment Scale. There are 8 subscales to this test. Items were scored in such a way that they could be compared to standardized norms. The standardized norms by definition have a mean score of 50 and a standard deviation of 10. Any mean scores above 50 for the pilots presented in Table 1 indicate above average ratings, and any mean scores below 50 indicate below average ratings.

Table 1

WORK ENVIRONMENT SCALE

| | MEAN | S.D. |
|---|---|---|
| Involvement | 52.41 | 13.66 |
| Autonomy | 53.55 | 17.08 |
| Task Orientation | 55.04 | 15.77 |
| Work Pressure | 55.67 | 14.09 |
| Clarity | 49.31 | 14.84 |
| Control | 56.84 | 11.93 |
| Innovation | 38.88 | 12.33 |
| Physical Comfort | 50.29 | 13.86 |

Mean: Average T-Score; norms are based on mean = 50 and S.D. = 10, pilot scores above 50 are above test sample norms, and pilot scores below 50 are below test sample norms.

S.D.: Population standard deviation (a measure of variability about the mean; 68% of the cases fall between plus and minus 1 S.D.)

The Involvement Scale reflects the degree to which workers are committed to, or enthusiastic about, their work. The pilots' response to this item is slightly above average.

The Autonomy Scale reflects the degree to which workers feel they can make decisions consistent with their level of responsibility. The pilots are slightly above average in this item. One reason their response is not higher is that, while the pilots are responsible for making decisions on the ships, there are decisions that are out of their control, such as decisions about assignments (a pilot not accepting an assignment loses one day's pay) and when particular ships will be ready to move.

The Task Orientation Scale reflects the degree to which pilots perceive that the environment emphasizes efficiency in getting the job done. The response is approximately 1/2 standard deviation above the mean, which places the pilots, as a group, at the 69th percentile. Such a rating is consistent with the time element of the job and the importance of never keeping a ship waiting.

The Work Pressure Scale reflects the degree to which individuals perceive pressure on the job. The pilots' response is at slightly more than one-half of the standard deviation above the mean, with considerable variability around the mean. With a response at approximately the 70th percentile, the pilots on the whole perceive an above average degree of work pressure. On average, however, their perception is not of extreme pressure.

The Clarity Scale reflects the degree to which individuals perceived that expectations for their performance are clearly communicated. This rating is very close to average.

The Control Scale is a measure of the degree to which individuals perceive that their activities are controlled by the system. This scale is approximately two thirds of a standard deviation above the mean and has the smallest standard deviation of the eight scales. To an above average degree, although not to an extreme degree, the pilots perceive that their activities are controlled by the system, and their perception is fairly consistent from one pilot to another.

The Innovation Scale reflects the degree to which pilots feel that their job allows for innovation or creativity. The response is significantly below average, as would be expected for this type of job. The job requires the pilots to do a particular task well and efficiently; it is not the kind of job that allows for creativity and innovation, nor would such be desirable. Piloting a ship or piloting an airplane or driving a bus do not become effective activities with innovation or creativity; indeed, those traits could actually pose a threat to the goals of these activities.

The Physical Comfort Scale reflects the degree to which individuals perceive their physical working environment to be comfortable. The rating here is very close to average, indicating that, on average, the pilot population does not perceive its working environment to be either more or less physically comfortable or uncomfortable than the working population at large.

Overall, the Work Environment Scale indicates that the pilots feel above average work pressure--although not to an extreme degree. They are also above average in their feeling that their activities are controlled by the system. They feel that their job does not allow for much in the way of creativity or innovation. They feel an average degree of physical comfort in the work.

## Job Stress Questionnaire

The Job Stress Questionnaire is comprised of 15 items rated on a five-point scale. As indicated earlier, these items have been used in numerous research studies and are usually applicable to most jobs. Table 2 presents the highest 5 items from the Job Stress Questionnaire. The stress item rated highest by the pilots is "having to decide things where mistakes could be quite costly." This rating is highly consistent with what we know about the job of the pilots since one

Table 2

JOB STRESS QUESTIONNAIRE*

| | RANK | MEAN | S.D. |
|---|---|---|---|
| Having to do or decide things where mistakes could be quite costly | 1 | 4.14 | 1.26 |
| How often does your job require you to work very hard (physically or mentally) | 2 | 4.00 | 0.93 |
| Feeling that your job tends to interfere with your family life | 3 | 3.23 | 1.36 |
| How often does your job require you to work very fast | 4 | 3.02 | 0.93 |
| How often does your job leave you with little time to get everything done | 5 | 2.54 | 1.12 |

* Top 5 of 15 items

Rank: 1 = Most stressful
5 = Least stressful

Mean: Average rating on a 5-point scale with 5 = "nearly all the time" and 1 = "not at all."

S.D.: Population standard deviation (a measure of variability about the mean; 68% of the cases fall between plus and minus 1 S.D.)

mistake could be extremely costly-- financially as well as in other ways. The second highest item is the degree to which they perceived their job to require very hard work, either physical or mental. An average rating of 4 is significantly high, especially since the standard deviation is relatively low. The third item is a tendency for the job to interfere with their family life. The rating on this item is significant, related as it is to the disruption in social life and planning of family activities that can occur as a result of their changing work schedules.

At the other extreme of the Job Stress Questionnaire was the lowest rated item which is "feeling trapped in a job you do not like but cannot change and cannot get out of." The mean rating on this was 1.48, which indicates that the pilots do not feel trapped in a job that they do not like. They have a fairly high degree of satisfaction with the type of work they do, which will be seen in some data presented later. The second lowest item was "not knowing just what the people you work with expect of you," with an average rating of 2.00. This rating reflects the fact that there is little ambiguity about what is expected in their jobs, and expectations for their performance are quite clear to them.

Potential stress factors

Table 3 lists 20 items that were identified from the interviews and from previous literature as being potentially stressful. They are ranked in terms of the ratings given to them by the 52 responding pilots. It is somewhat difficult to make comparisons to other populations without normative data. But it is possible to get a ranking of the stress factors so as to identify what the pilots perceive to be the more stressful and the less stressful aspects of the job. It should be kept in mind when looking at these scores that the ratings on each item are independent from each other in the sense that ratings on one item do not statistically affect ratings on another item: all items could have high ratings, or all items could have low ratings, or, as in this case, some items could have higher average ratings than others.

Table 3

POTENTIAL STRESS FACTORS

| | RANK | MEAN | S.D. |
|---|---|---|---|
| Attitudes and philosophy of Commission | 1 | 7.37 | 2.92 |
| Weather conditions (fog, visibility, rain, wind, rough seas, etc.) | 2 | 7.01 | 2.77 |
| Boarding the pilot boat from a vessel | 3 | 6.80 | 2.85 |
| Docking a vessel | 4 | 6.23 | 2.55 |
| Approaching the dock | 5 | 5.76 | 2.72 |
| Irregularity or unpredictability in assignment times after the first call from the dispatcher | 6 | 5.48 | 2.68 |
| Level of responsibility | 7 | 5.39 | 3.12 |
| Undocking a vessel | 8 | 5.12 | 2.30 |
| Boarding a vessel from the pilot boat | 9 | 5.12 | 2.84 |
| Anticipatory period between the dispatcher's call and the actual commencement of work assignment | 10 | 5.04 | 2.57 |
| Delays (due to weather, changes in arrival or departure times, etc.) | 11 | 5.00 | 2.54 |
| Time pressure/time demands | 12 | 4.98 | 2.60 |
| Average number of hours worked per week | 13 | 4.87 | 2.62 |
| Spouse's reaction to your work schedule | 14 | 4.81 | 2.76 |
| Time spent on pilot boat | 15 | 4.69 | 2.81 |
| Length of time between assignments | 16 | 4.33 | 2.64 |
| Differences in vessel characteristics | 17 | 4.21 | 2.64 |
| Language barriers with the crew | 18 | 3.52 | 2.60 |
| Differences from one crew to the next | 19 | 3.48 | 2.42 |
| Sea Sickness | 20 | 3.42 | 3.16 |

Table 3, continued

Rank: 1 = most stressful
20 = least stressful

Mean: Average rating on a 10-point scale with 10 = "extremely stressful" and 1 " non-stressful."

S.D.: Population standard deviation (a measure of variability about the mean; 68% of the cases fall between plus and minus 1 S.D.)

At the top of the list is "attitudes and philosophy of the Commission," with an average rating of 7.37. It was clear both in the interviews and from these data that the pilots have some very definite concerns about the Commission, and that decisions being made by the Commission are very important in the minds of the pilots. In an absolute sense, an average rating of 7.37 is significantly high. Although this finding accurately reflects the pilots' concern in February 1986, when the pilots responded to the questionnaires, we observed an improvement in the pilots' attitude toward the Commission during the remainder of the study.

The second highest item is "weather conditions (fog, visibility, rain, wind, rough seas, etc.)," with a mean rating of 7.01. Contributing to this rating is the unpredictability of what can happen in adverse weather conditions, and this would bear on the issue of the highest rated item from the Job Stress questionnaire, namely, "having to decide things where mistakes could be quite costly."

The third highest item is "boarding the pilot boat from a vessel" rated at 6.80. This appears to be a significant rating and reflects the perception of danger associated with this activity when there are poor weather conditions and high swells.

The next two items are "docking a vessel" (6.23) and "approaching the dock" (5.76). Approaching the dock represents the anticipatory period leading up to the actual docking. This is a time when mistakes would be very costly. Not only the actual docking, but the anticipation of such, is stressful.

At the low end of the scale are "sea sickness" (3.42), "differences from one crew to the next" (3.48), and "language barriers with the crew" (3.52). The lowest possible rating on these items is a "1," which was described as non-stressful.

In the middle range are such items as "the unpredictability in assignment times" (5.48), "level of responsibility" (5.39), "undocking a vessel" (5.12), "boarding a vessel from the pilot boat" (5.12), "the anticipatory period between the dispatchers call and the actual commencement of work" (5.04), and "time pressures/time demands" (4.98). Related to the goal of this project "the average number of hours worked per week" was rated as a 4.87 and the "length of time between assignments" as rated as a 4.33. While these ratings are well above one, the rank order of these two items was 13th and 16th, respectively.

The anticipatory period between the dispatcher's call and the actual commencement of the work was rated as a mid-level stress factor. It is during this period of time that a pilot will begin anticipating what he must do; and it is also during this time that the sleep/wake cycle, family plans, or social activities can be disrupted. During the two-month study of pilot activities and pilot workload, there were 2,051 telephone calls between the dispatchers and pilots. Dispatchers originated 61 percent of the calls. Usually, these calls related to specific pilotage assignments and, once knowing the assignment, many of the pilots tend to think about and anticipate the problems associated with performing the specific piloting job.

Satisfaction/dissatisfaction. Table 4 presents a continuum of 15 items that the pilots rated on the dimension of satisfaction/dissatisfaction. The higher the mean score, the more satisfied were the pilots. Ranked number one as highly satisfying is "type of work (nature of the job itself)," with a mean rating of 8.85. This is a very high average rating on a ten-point scale. Basically, what this means is that they like being pilots despite the fact that they are stressed by a variety of factors.

Also rated highly satisfying was the sleep that they get during ATO and the level of support from co-workers. Although financial compensation was rated as the fourth highest among the 15 items, the absolute value of the scores dropped off fairly dramatically between the rank of 3 and the rank of 4. The financial compensation, work load, and the length of time between assignments show mild satisfaction. The quality of sleep when they are working-- whether it

Table 4

SATISFACTION/DISSATISFACTION

| | RANK | MEAN | S.D. |
|---|---|---|---|
| Type of work, (nature of the job itself) | 1 | 8.85 | 1.90 |
| Quality of sleep patterns during ATO | 2 | 8.56 | 1.94 |
| Level of support from co-workers | 3 | 7.08 | 2.62 |
| Financial compensation | 4 | 5.83 | 2.59 |
| Work load | 5 | 5.64 | 2.43 |
| Length of time between assignments | 6 | 5.60 | 2.59 |
| Work hours | 7 | 5.33 | 2.53 |
| The 12-hour rule | 8 | 5.19 | 2.92 |
| Eating patterns during work periods | 9 | 4.64 | 2.54 |
| Effects of work schedule on family life | 10 | 4.62 | 2.49 |
| Quality of sleep during work periods | 11 | 4.12 | 2.51 |
| Effects of work schedule on social life | 12 | 4.04 | 2.45 |
| Quality of sleep between the time you are called by the dispatcher and the time you leave your home | 13 | 3.71 | 2.58 |
| Quality of sleep during the day time of work periods | 14 | 3.54 | 2.69 |
| Quality of sleep on the pilot boat | 15 | 3.14 | 2.54 |

Rank: 1 = most satisfying<br>15 = least satisfying

Mean: Average rating on a 10-point scale with 10 = "extremely satisfied" and 1 = "extremely dissatisfied."

S.D.: Population standard deviation (a measure of variability about the mean; 68% of the cases fall between plus and minus 1 S.D.)

is after being called by the dispatcher or during the day or on the pilot boat--is fairly dissatisfying. It appears that there is more dissatisfaction with sleep patterns than with eating patterns. The effects of their work schedule on their family life is mildly dissatisfying. Of all the items rated, those associated with the quality of sleep point to the area of most dissatisfaction.

Reactions to the job

This set of items was developed to help assess how the pilots respond to their working environment. It is one thing to perceive a job as being stressful or dissatisfying. It is another to understand how a person reacts or responds to that job. Table 5 presents the 20 emotional and cognitive reactions that were derived from the interviews and the literature. The most significant reaction, with a rank of 1 and a mean of 5.39, is "tired," The second highest rated item is "fatigue" with a mean of 5.12, and the third highest rating is on the response "anxious."

At the other extreme, pilots do not appear to get "confused" or "spaced out" as a reaction to their working environment. It is also interesting that hostility and anger reactions are relatively low, although irritability and frustration are somewhat higher. Three of the top four items appear to be related to disruption in the sleep/wake pattern. On the Satisfaction/Dissatisfaction items, the lowest satisfaction had to do with the quality of sleep they were getting. And on the Reactions to the Job, they tend to feel tired, fatigued, and unable to sleep, in addition to anxious and tense.

The pattern that emerged is that the sleep/wake disruption, which affects the synchronization of circadian rhythms in the body, is reflected in a poor quality of sleep during those periods that pilots are on duty or on call. These are the kinds of items that people rate as problem areas when they are doing shift work, particularly when they are rotating among different shifts.

Table 5

REACTIONS TO THE JOB

| | RANK | MEAN | S.D. |
|---|---|---|---|
| Tired | 1 | 5.39 | 2.35 |
| Fatigued | 2 | 5.12 | 2.68 |
| Anxious | 3 | 4.77 | 2.67 |
| Unable to sleep | 4 | 4.75 | 2.77 |
| Wound-up | 5 | 4.49 | 2.70 |
| Tense | 6 | 4.47 | 2.69 |
| Apprehensive | 7 | 4.27 | 2.87 |
| Worried | 8 | 4.21 | 2.60 |
| Irritable | 9 | 3.85 | 2.42 |
| Frustrated | 10 | 3.71 | 2.66 |
| Grouchy | 11 | 3.48 | 2.48 |
| Nervous | 12 | 3.35 | 2.58 |
| Moody | 13 | 3.08 | 2.43 |
| Sluggish | 14 | 3.08 | 2.56 |
| Groggy | 15 | 3.08 | 2.68 |
| Angry | 16 | 2.96 | 2.35 |
| Depressed | 17 | 2.48 | 2.30 |
| Hostile | 18 | 2.40 | 2.11 |
| Spaced-out | 19 | 2.08 | 2.12 |
| Confused | 20 | 1.90 | 1.57 |

Rank: 1 = most intense reaction
15 = least intense reaction

Mean: Average rating on a 10-point scale with 10 = "severe problem" and 1 = "no problem."

S.D.: Population standard deviation (a measure of variability about the mean; 68% of the cases fall between plus and minus 1 S.D.)

Open ended questions

There was opportunity in this section for individuals to write in their comments.

As can be seen in Table 6, 58 percent of the pilots feel that, in general, there is sufficient time between assignments, and 42 percent feel that there is not. The average amount of time requested between assignments by the dissatisfied group was 25.40 hours. Comments in this regard included statements such as, "When there is not time between assignments for 2 to 3 days, that's when exhaustion sets in." There was a request for more time off for river assignments (even though Rule 51 allocates an additional ten hours between a river move and a subsequent pilotage). There was a statement to the effect that "cycle patterns" are established that do not allow for sufficient rest between assignments.

Item 3 asked them to choose hypothetically between an increase in compensation and more time between assignments. The results were that 52 percent would choose an increase in compensation, whereas 48 percent would choose more time between assignments. Some of the comments in this regard were that it was an "unfair choice," "unanswerable," "unfair question," and "no idea." Two people answered "both." This, of course, is not the kind of choice that people like to make, but sometimes getting people to make that choice on paper provides some insight into their concerns. That approximately half of the pilots would prefer more time between assignments than more compensation for what they are doing now is significant-- especially in view of their attitude toward the adequacy of their compensation (64 percent feeling it is inadequate--see below).

Item 4 asked the pilots what they considered the ideal number of bar pilots to be. The responses ranged from 50 to 75 with a fairly equal distribution of responses between these two extremes. The average number of pilots that the group, as a whole, would like to see is 58.

Table 6

OPEN-ENDED QUESTIONS

| | | |
|---|---|---|
| 1. Do you feel that in general or on average, there is sufficient time between assignments? | Yes: 58% | No: 42% |
| If no, what would you realistically like to see as the minimum amount of time between assignments? | Average: 25.40 hours | |
| 2. Do you feel that the compensation for your work is adequate? | Yes: 36% | No: 64% |
| If no, how much would reasonably be adequate? | Average: $127,620.00 | |
| 3. If you had to choose between (A) an increase in compensation and (B) more time between assignments, which would you choose? | (A) 52% | (B) 48% |
| 4. What do you feel (please be realistic, of course) the ideal number of bar pilots would be? | Average: 58.19 | |

Approximately 36 percent felt that compensation for their work was adequate, and approximately 64 percent felt that it was inadequate. The average compensation requested by those feeling that present levels were inadequate was $127,620 per year. Some of the written responses suggested that the river rates be higher. The most frequent written response had to do with comparing their compensation with that of other pilots in other ports. It was noted that San Francisco was the most difficult pilotage in the United States, and, therefore, they should be paid more.

Sleep Patterns

The current system for the bar pilots is to be on call for one-half month on and one-half month off. During the two weeks they are on call, the amount of time between assignments varies, and the assignments can occur at any time of the day or night. This has the effect of disrupting the sleep/wake cycle during the two-week period.

Disruptions in the sleep/wake cycle cause a desynchronization to circadian rhythms, the biological rhythms that are keyed into a 24 hour clock. They include such physiological and biochemical factors as: body temperature, blood pressure, urine volume, constituents of the urine, blood sugar levels, desire to eat, desire to sleep, and numerous others. These circadian rhythms are usually synchronized when a person is waking and sleeping at the same time each day. When a person changes the sleep/wake cycle, the circadian rhythms attempt to catch up to the new sleep/wake pattern, but they do so at different rates, which has the effect of desynchronizing the circadian rhythms, which inevitably causes a stress to the body.

When a person goes through a 180 degree shift in the sleep/wake pattern, which is the maximum amount that can occur, it takes up to three weeks for the circadian rhythms to become resychronized. A person who goes to sleep at 11:00 p.m. and travels half way around the world and continues to go to sleep at 11:00 p.m. in the new time zone will have achieved a 180 degree shift. If a person who goes to sleep at 11:00 PM changes his sleep/wake pattern at home and begins to go to sleep at 11:00 AM, he also experiences a 180 degree shift. When the amount of shift that occurs is less than 180 degrees, the amount of time for resynchronization of the circadian rhythms becomes less. Circadian rhythm desynchronization is inevitable when changes occur in the sleep/wake pattern, and such disruption occurs to everyone who makes such changes.

The disruption to the sleep/wake cycle, and, thus to the circadian rhythms of the body, is an inherent aspect of the pilots' job, since they must, in fact, be responsive to the ships' arrivals and departures regardless of the time the ships come in. The literature on shift work indicates that such disruption to the sleep/wake pattern is stressful both physiologically and psychologically. People who have continual disruption to their sleep/wake pattern report more physical illness, more physiological disruption, and more psychological problems than their counterparts working regular shifts. Such difficulties include problems with digestion and elimination. There is also increased susceptibility to anxiety, irritability, depression, tiredness, and fatigue.

During the two weeks they are on call, the pilots' sleep/wake pattern does not become 180 degrees out of phase. During this period there is some, but less than complete, overlap in terms of the time that they are falling asleep from one day to the next. Nevertheless, during the time that the pilots are on call, their sleep pattern is disrupted, and this disruption contributes to the overall level of stress on the job. From an analysis of the kind of schedule the typical pilot is subject to, the two weeks off is probably sufficient time for a re-synchronization of circadian rhythms and dissipation of fatigue.

An alternative to the current "two weeks on--two weeks off schedule, which some of the pilots are electing to do by trading with other pilots, is a "one week on-- one week off" schedule. The result of being on call for one week would not be so disrupting to the circadian rhythms in the body as would being on call for two weeks.

Therefore, one week of recovery following one week of being on call would probably be sufficient for most pilots to recover biologically.

In general, people who are offered alternative work schedules often prefer rapidly rotating shifts, i.e. working two or three different shifts within 1 week rather than more slowly rotating shifts. A "one week on-- one week off" vs. a "two week on--two week off" pattern does not make much difference from a physiological or biological rhythm standpoint. From a psychological standpoint, however, the perception is often that a person can do most anything for one week if he can "see the light at the end of the tunnel." At the other extreme might be a shift schedule requiring one month on, followed by one month off. A person would not need the entire month off to recover from a month of working, and the perception of the difficulties associated with continual work for one month would probably outweigh any other advantages of such a schedule.

Another alternative pattern would be two or three weeks on, followed by one or two weeks off. If the work load and the number of pilots stays constant, the effect of this type of schedule would be to create more time between assignments. This type of schedule (20 days on, 10 days off during winter and 60 days on, 30 days off during summer), however, was rejected by the pilots in favor of a "one-half month on--one-half month off" schedule.

In one study, "Health Consequences of Shift Work," it was discovered that the degree to which individuals adapted to their shift pattern was related to how much they liked or disliked it. In other words, if an individual was working a shift pattern that he or she was satisfied with, that person would adapt better to that shift than would a person who was dissatisfied with the shift schedule. It is important, therefore, that pilots' preference for shift schedules be maximized. If, for example, the current "two week on— two week off" pattern is maintained, and, if some of the pilots do not like this schedule, it would be psychologically and physiologically beneficial for those disliking it to have some flexibility built into the system whereby some other shift pattern accommodating the same amount of work could be offered as an alternative.

## Conclusions

The findings in our study are consistent with findings from previous pilot studies in terms of stress factors, difficulties inherent in the job, and disruption to the sleeping and eating patterns. Other studies of pilots have pointed to emotional stress, physical stress associated with boarding and disembarking, an intensive mental work load, fatigue, disruption to the sleep/wake cycle, and uncertainty in working hours. While fortunately not an apparent problem in San Francisco, other studies have also shown higher mortality rates due to cardiovascular disease for pilots than for the population at large. This phenomenon is consistent with studies that show people working rotating shift schedules to have higher rates of coronary heart disease than people working fixed or day time shifts.

Previous research on pilots indicates that the pilots like their work and are generally proud of their skills and profession. The results of our study are consistent: pilots like their work and feel reasonably good support from their co-workers. The general literature on the effects of shift work indicates that some of the most common effects from disruption of the sleep/wake cycle are tiredness, fatigue, insomnia, and irritability: the findings in our study are consistent with these studies as well.

### Job stress

The pilots perceive their job to be stressful. The degree of stress is above average, but it is not extreme. It would best be described as moderate to moderately severe. Some of the more significant factors contributing to stress on the job include: the attitudes and philosophy of the Commission; adverse weather conditions; boarding the pilot boat from a vessel; docking a vessel; and approaching the dock. The job is also characterized by competition among the pilots; having to decide things where mistakes could be quite costly; and having to work very hard in response to the demands of the job. A lesser, yet significant, degree of stress is seen with such factors as: undocking a vessel; boarding a vessel from the pilot boat; anticipating an assignment after a call from the dispatcher; and time demands. The disruption to the sleep/wake pattern that inevitably occurs as a result of varying times to commence work desynchronizes circadian rhythms and acts as an additional source of stress which can add to, or synergize with, other sources of stress.

Job satisfaction

As a group, the pilots are quite satisfied with the nature of their work: piloting ships. They also feel a reasonably good degree of support from their co-workers. There is considerable dissatisfaction in the quality of sleep that they get during work periods, whether that sleep is at home or on the pilot boat. Poor quality of sleep is inevitable when there is disruption to the sleep/wake cycle which can be caused by the continually changing work times that pilots are subjected to. To a moderate degree, the work schedule also interferes with family life during work periods, in that it is difficult to schedule family and social activities during work periods because of the unpredictability of work hours.

The pilots as a group are neither highly satisfied nor highly dissatisfied with their level of compensation. While some individuals are quite satisfied, others are quite dissatisfied. Treating the group as a whole, it would be best to characterize them as slightly dissatisfied with their level of compensation.

ATO rotation schedule

Considering the previous literature, the known effects on the circadian rhythms as a result of changing sleep/wake patterns, and the specific nature of the pilot's job, we would conclude that the existing one-half month on--one-half month off" causes circadian rhythm desynchronization but also allows time for full recovery. The most acceptable alternative from the standpoint of physiological disruption would be "7 days on--7 days off." A pattern of "2 weeks on--1 week off" or "3 weeks on--1 week of," even though such patterns allow more time between assignments, may not leave enough time for full recovery from circadian rhythm desynchronization.

From a psychological standpoint, workers generally find it more tolerable to work for more limited periods of times, such as 7 to 14 days, without a break if there is "light at the end of the tunnel" than to attempt three or four weeks of continuous work—even though the longer work period might be followed by a longer rest period. From a physiological standpoint, it would be best to have people working fixed shifts, i.e., working at the same time every day so that they were sleeping at the same time every day. For practical reasons, in fairness to all pilots, and because of the unpredictability of scheduling, this would be impossible.

Work situation

Tiredness and fatigue are two of the pilots' most common complaints. These reactions occur as a result of the disruption to the sleep/wake cycle. Anxiety and tension are also significant, and these reactions are in response to the dangerous element of the job and to the costly consequences that can occur if a mistake is made.

Average rest period

Slightly over half the pilots feel that the length of time between assignments is sufficient. Of the 42 percent who feel that the length of time between assignments was insufficient, the average number of hours requested between assignments was 25.40. Our survey found that the average rest period was 20.75 hours, 3.5 hours less than some of the pilots requested. Of course, this was the slack period of the year, and we note that there was a dramatic drop in the length of rest period during the six intermittent peak periods.

Minimum Rest Period

The current practice is to allow at least eight hours between pilotage assignments. The average rest period exceeds this minimum value most of the time, but we observed that during peak traffic periods, rest periods dropped close to or even broke through the eight hour lower limit. From a physiological point of view, it is important that most people have at least the opportunity to get a full eight hours of sleep. When the pilots have only a minimum rest period of eight hours, it is impossible to get that amount of sleep. When the pilots have only a minimum rest period of eight hours, it is impossible to get that amount of sleep. Even an MRP as long as ten hours would barely provide the necessary rest, depending on personal and family time demands.

Number of pilots

The group of pilots on average would like to see the total number of pilots set at 58 in contrast to the existing 53, which represents an increase of approximately 10 percent.

Alternative work design

There is significant evidence in the literature that, when individuals like or have a preference for the shift they are working, they tend to adapt better both physiologically and psychologically to that shift schedule, in contrast to the case when they do not like the schedule they are working. We think that it would be worthwhile to construct various work hour alternatives with differing amounts of time between assignments but covering the same volume of work and then to present these alternatives to the pilots for their preferences. It may be possible to maximize preference by having different work patterns for different people, whereby each person is still doing the same amount of work within a system that is equitable to everyone.

Stress management

It would be worthwhile considering a stress management program for the pilots. The pilots perceive a significant number of stress factors in their work. They also perceive that there is little that can be done about them. While it is true that many of the elements of piloting are unchangeable, it is quite possible that they can learn to change or modify some of their reactions to these stress factors. The results of effective stress management programs are usually increased work efficiency, decreased errors, and increased satisfaction with the work.

# III. PILOT WORKLOAD

## Methodology

The primary data required for our analysis consisted of: 1) the time required to perform the various piloting and non-piloting functions; and 2) an accounting of the vessel movements duing the period. Regarding the first set of data, all pilots were requested to keep a detailed accounting of their time broken down by 28 different activities, including telephone calls to and from the dispatchers. These time breakdowns could be as small as 15-minute increments (by entering a slash in the appropriate block with two activities, one above the slash and the other below). Table 7a shows the Pilot Time Report used by the pilots to record the data from January 16, 1986 to March 15, 1986. After the Pilot Time Reports were collected and analyzed, two additional activities were added: one for sick leave and the other for Accumulated Time Off (ATO). There are, in total, almost 300,000 lines of data on pilot workload in our PC data base.

Table 7b (the reverse side of the Pilot Time Report) presents the ship movement data that the pilots were asked to report in association with their time data. There are approximately 1,500 lines of ship data in the data base. This figure is somewhat higher than the 1,400 ship movements recorded during the two-month period because of light pilot movements and because, on several occasions, two pilots handled a single ship.

## Pilot Activity Times

### Average bar movements

Table 8 presents the average times associated with a bar move. On the average, during the sample period, it took 13 3/4 hours from the time the pilot left his home until he returned to his home, 11 3/4 hours from the time he entered the office at the start of the assignment until he left the office at the completion of the assignment.

Table 7a

# PILOT'S TIME REPORT

PILOT'S TIME REPORT

Pilot Capt: ______________________

DATES

| TIME | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0000 - 0030 | | | | | | | |
| 0030 - 0100 | | | | | | | |
| 0100 - 0130 | | | | | | | |
| 0130 - 0200 | | | | | | | |
| 0200 - 0230 | | | | | | | |
| 0230 - 0300 | | | | | | | |
| 0300 - 0330 | | | | | | | |
| 0330 - 0400 | | | | | | | |
| 0400 - 0430 | | | | | | | |
| 0430 - 0500 | | | | | | | |
| 0500 - 0530 | | | | | | | |
| 0530 - 0600 | | | | | | | |
| 0600 - 0630 | | | | | | | |
| 0630 - 0700 | | | | | | | |
| 0700 - 0730 | | | | | | | |
| 0730 - 0800 | | | | | | | |
| 0800 - 0830 | | | | | | | |
| 0830 - 0900 | | | | | | | |
| 0900 - 0930 | | | | | | | |
| 0930 - 1000 | | | | | | | |
| 1000 - 1030 | | | | | | | |
| 1030 - 1100 | | | | | | | |
| 1100 - 1130 | | | | | | | |
| 1130 - 1200 | | | | | | | |
| 1200 - 1230 | | | | | | | |
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| 1800 - 1830 | | | | | | | |
| 1830 - 1900 | | | | | | | |
| 1900 - 1930 | | | | | | | |
| 1930 - 2000 | | | | | | | |
| 2000 - 2030 | | | | | | | |
| 2030 - 2100 | | | | | | | |
| 2100 - 2130 | | | | | | | |
| 2130 - 2200 | | | | | | | |
| 2200 - 2230 | | | | | | | |
| 2230 - 2300 | | | | | | | |
| 2300 - 2330 | | | | | | | |
| 2330 - 2400 | | | | | | | |

| CODE | ACTIVITIES |
|---|---|
| DC | Telephone call from dispatcher |
| PC | Telephone call to dispatcher |
| 01 | Number One Pilot (at home) |
| 02 | Travel, home to ship |
| 03 | Travel, home to office |
| 04 | Travel, office to ship-overland |
| 05 | Travel, office to ship-water (DRAKE or other) |
| 06 | Travel, office to station (DRAKE or lite pilot) |
| 07 | Travel, station to office (DRAKE or lite pilot) |
| 08 | Travel, ship to office-water (DRAKE or other) |
| 09 | Travel, ship to office-overland |
| 10 | Travel, office to home |
| 11 | Travel, ship to home |
| 12 | Bridge time, Bar move |
| 13 | Bridge time, Bay move |
| 14 | Bridge time, River move |
| 15 | Station boat time |
| 16 | Preparing for job |
| 17 | Paper work (job clean-up) |
| 18 | Delayed at office (delayed sailing) |
| 19 | Standby at ship (delayed sailing) |
| 20 | Standby at office (between Bay moves) |
| 21 | Weathered in (on ship) |
| 22 | Weathered in (to/from ship) |
| 23 | Association administration (monthly meetings, etc.) |
| 24 | Other public service |
| 25 | Training---trainee |
| 26 | Training---trainer |

Time called back when on A.T.O.

| | Day | Hour |
|---|---|---|
| From | ____ | ____ |
| To | ____ | ____ |

Sick leave

| | Day | Hour |
|---|---|---|
| From | ____ | ____ |
| To | ____ | ____ |

Table 7b

# PILOT'S TIME REPORT

| Ship Name | Boarding Date | Boarding Time | Boarding Area | Debarking Area | Duty: Piloting | Duty: Lite Pilot |
|---|---|---|---|---|---|---|
| | | | | | | |
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## Area Codes

| | |
|---|---|
| SF | San Francisco Waterfront |
| OAK | Oakland, Alameda, Richmond Outter Harbor |
| RED | Redwood City |
| RICH | Richmond Inner Harbor and docks north of the Richmond-San Rafael Bridge but south of Point San Pablo. |
| OLEUM | Oleum and vicinity. |
| CAR | Carquinez Straits and vicinity. |
| MART | Martinez and vincinity (including Benicia). |
| CHIC | Port Chicago |
| SAC | Sacramento |
| STK | Stockton |
| STA | Station Boat |
| ALC | Alcatraz |
| ANC5 | Anchorage 5 |
| ANC7 | Anchorage 7 |
| ANC8 | Anchorage 8 |
| ANC9 | Anchorage 9 |
| OFF | Office |

The data contained in Table 8 represent a two-way move, i.e., a situation where the pilot takes a ship out across the bar and brings a second ship back in. If the pilot were to deadhead (via the Drake or as a "light" pilot) on one of those legs, the total average time would have been one hour less than those times shown in Table 8. Not all of the pilot trips are two-way moves: There is a significant number of one-way moves due to the randomness of the ships arriving at the bar and sailing from the bay, as well as the various pilot work rules. During the survey period, 17.2 percent of the inbound trips made by pilots were light trips, 19.5 percent of the outbound trips were light trips.

The pilots have a work rule that states that the pilot on the station boat will be relieved if his bridge time (from the time of the assignment) outbound plus the station boat time would exceed 12 hours upon boarding an inbound vessel or would exceed 8 hours upon boarding an inbound vessel if that inbound vessel was going to Redwood City or north of San Pablo (Rule Number 11 and Rule Number 54, respectively). Note that, on the average, the outbound bridge time plus the station boat time was six hours--well under the limits of both mandatory relief rules.

Average bay movements

Table 9 presents the average times for a bay move: an average of 15 hours home-to-home, 13 hours office-to-office. Note that the average assignment time is only seven hours before boarding the second ship. Rule Number 55 states that the pilots will serve 12 hour shifts. Accordingly, there is sufficient time, on the average, to handle two bay moves per shift.

Average river movements

Table 10 presents the average times for a river move: also an average of 15 hours home-to-home, and 13 hours office-to-office. The total home-to-home time and office-to-office time for all three types of moves are approximately the same: about one-half day. The average bridge time of 8.75 hours on a river move, however, is strenuous work,

Table 8

BAR MOVE TIMES
(Hours)*

| | |
|---|---|
| Travel, home to office | 1:00 |
| Job preparation | 0:15 |
| Travel, office to ship | 0:45 |
| Bridge time | 2:30 |
| Station boat | 3:30 |
| Bridge time | 2:45 |
| Travel, ship to office | 0:45 |
| Job cleanup** | 0:30 |
| Delays** | 0:45 |
| Travel, office to home | 1:00 |
| Total excluding travel between home and office | 11:45 |
| Total including travel between home and office | 13:45 |

Note: Total time is reduced one hour if pilot travels to/from station as light pilot.

* Times rounded to the nearest quarter hour.

** Job Clean-up: Invoice preparation, dissemination of new local knowledge, discussion of completed jobs, equipment stowage, preview of following day's dispatch, record keeping and other minor administrative duties.

Delays: Delay at office due to change in schedule, at ship due to delayed sailing or enroute due to weather.

Table 9

BAY MOVE TIMES
(Hours)*

| | |
|---|---|
| Travel, home to office | 1:00 |
| Job preparation | 0:15 |
| Travel, office to ship | 0:45 |
| Bridge time | 3:00 |
| Travel, ship to office | 0:45 |
| Standby time** | 2:30 |
| Travel, office to ship | 0:45 |
| Bridge time | 3:00 |
| Travel, ship to office | 0:45 |
| Job cleanup** | 0:30 |
| Delays** | 0:45 |
| Travel, office to home | 1:00 |
| Total excluding travel between home and office | 13:00 |
| Total including travel between home and office | 15:00 |

* Times rounded to the nearest quarter hour.

** Standby Time: Between bay moves (or early arrival at an outbound ship to save travel expenses).
Job Clean-up: Invoice preparation, dissemination of new local knowledge, discussion of completed jobs, equipment stowage, preview of following day's dispatch, record keeping and other minor administrative duties.
Delays: Delay at office due to change in schedule, at ship due to delayed sailing or enroute due to weather.

Table 10

RIVER MOVE TIMES
(Hours)*

| | |
|---|---|
| Travel, home to office | 1:00 |
| Job preparation | 0:15 |
| Travel, office to ship | 1:15 |
| Bridge time | 8:45 |
| Travel, ship to office | 1:15 |
| Job cleanup** | 0:30 |
| Delays** | 1:00 |
| Travel, office to home | 1:00 |
| Total excluding travel between home and office | 13:00 |
| Total including travel between home and office | 15:00 |

* Times rounded to the nearest quarter hour.

** Job Clean-up: Invoice preparation, dissemination of new local knowledge, discussion of completed jobs, equipment stowage, preview of following day's dispatch, record keeping and other minor administrative duties.
Delays: Delay at office due to change in schedule, at ship due to delayed sailing or enroute due to weather.

involving a high concentration of effort conning ships up or down the restricted river channels. This long time might be the reason for Rule Number 51, which, in effect, states that pilots on river moves get an extra ten hours of rest before the next assignment.

The average times of the various piloting functions presented in Tables 8-10 can be used in part to determine the required number of active pilots "on the board," assuming the vessel schedules are such that the pilots can work at maximum productivity. Obviously, additional pilots would be required because of administrative time, sick leave, accumulated time off (ATO), etc.

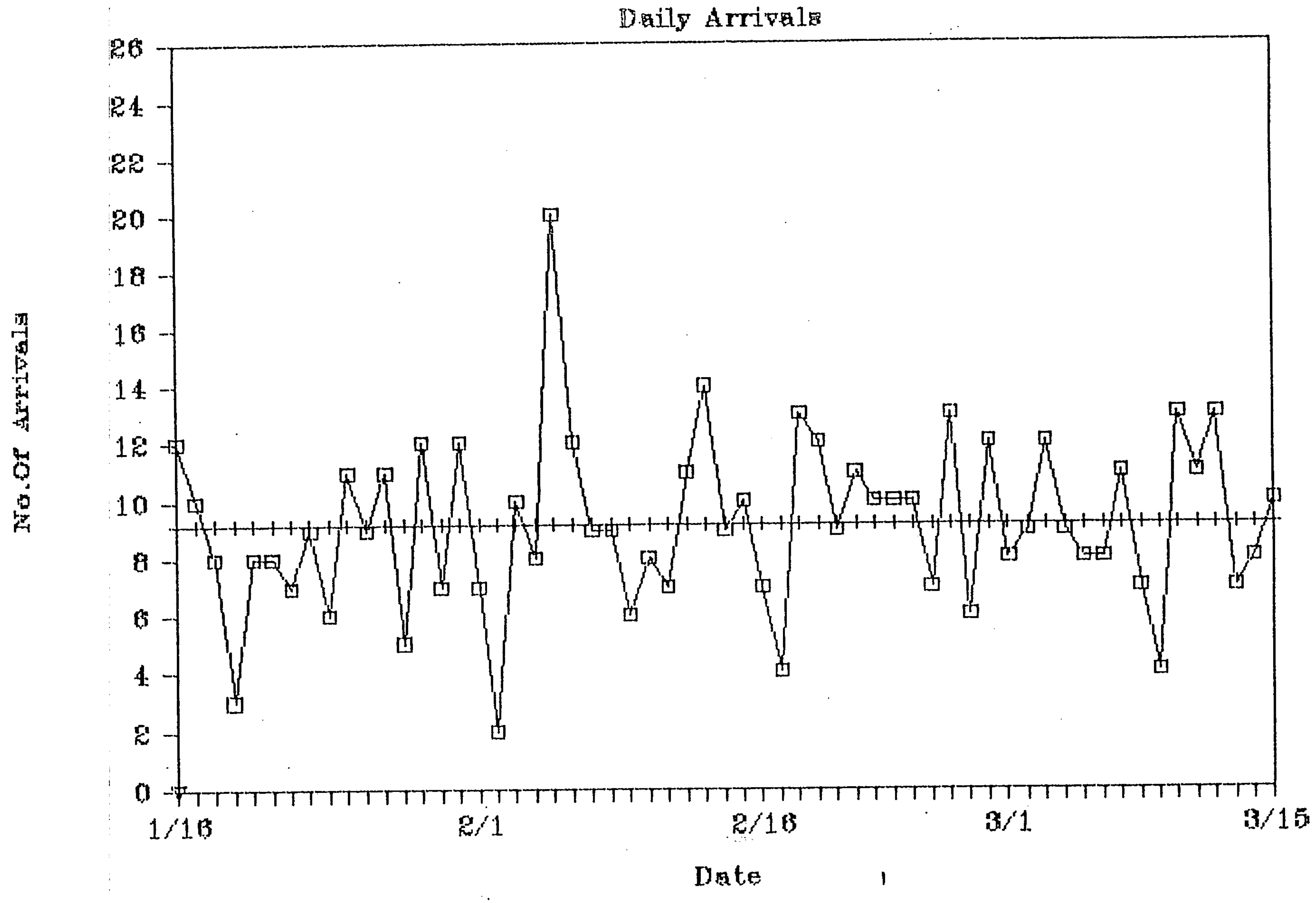
## Fluctuations in Demand for Pilots

Figure 1 represents the daily vessel arrivals for the sample period analyzed in the study. It includes only the arrivals over the bar. The straight line in the figure represents the average arrivals of approximately 9.33 ships per day. The number of arrivals actually varied from two to 20. The peak is more than twice the average. Even the second highest peak (14 arrivals) is 50 percent greater than the average.

Suppose for the sake of argument that there were only 14 pilots available (enough to cover all but the highest peak) and that each pilot could serve one arrival per day, counting his rest period and the fact that in most cases he will also be piloting a sailing. With 14 pilots on the board, six of the arrivals on February 5 would have been delayed. Two of those six arrivals could have been handled on February 6, when the number of arrivals was 12. The other four could have been handled on the 6th only by bumping four of the six February 6 arrivals over until February 7. In summary, then, 10 ships would be delayed about one day per ship.

Fortunately, the overall peak-to-average ratio is not quite so bad as occurred on February 5. There are other demands for pilot services for sailings, bay moves, river moves, administrative times, etc. All of these other demands when added together tend to smooth out the total

Figure 1



Daily Arrivals
No.Of Arrivals
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1/16
2/1
2/16
3/1
3/15
Date

peak-to-average ratio. Nevertheless, there is a tremendous fluctuation in pilot activity.

Figure 2 represents the maximum number of pilots engaged in some activity during any given day. The pilot could have been piloting ships, travelling to and from home, performing administrative duties, etc. In other words, he was engaged in activity codes 2 (enroute from home to a ship) through 26 (training-trainer) as indicated on Table 7a. As a way of explanation of Figure 2, consider January 16. At some point during the day, 17 pilots were engaged in some activity; all other pilots were at home between assignments, on sickleave, or on ATO. The average number of pilots engaged, represented by the horizontal line in Figure 2, was 13. The minimum was six, the maximum 24. No matter what analysis is performed, the demand for pilot service varies significantly from day to day.

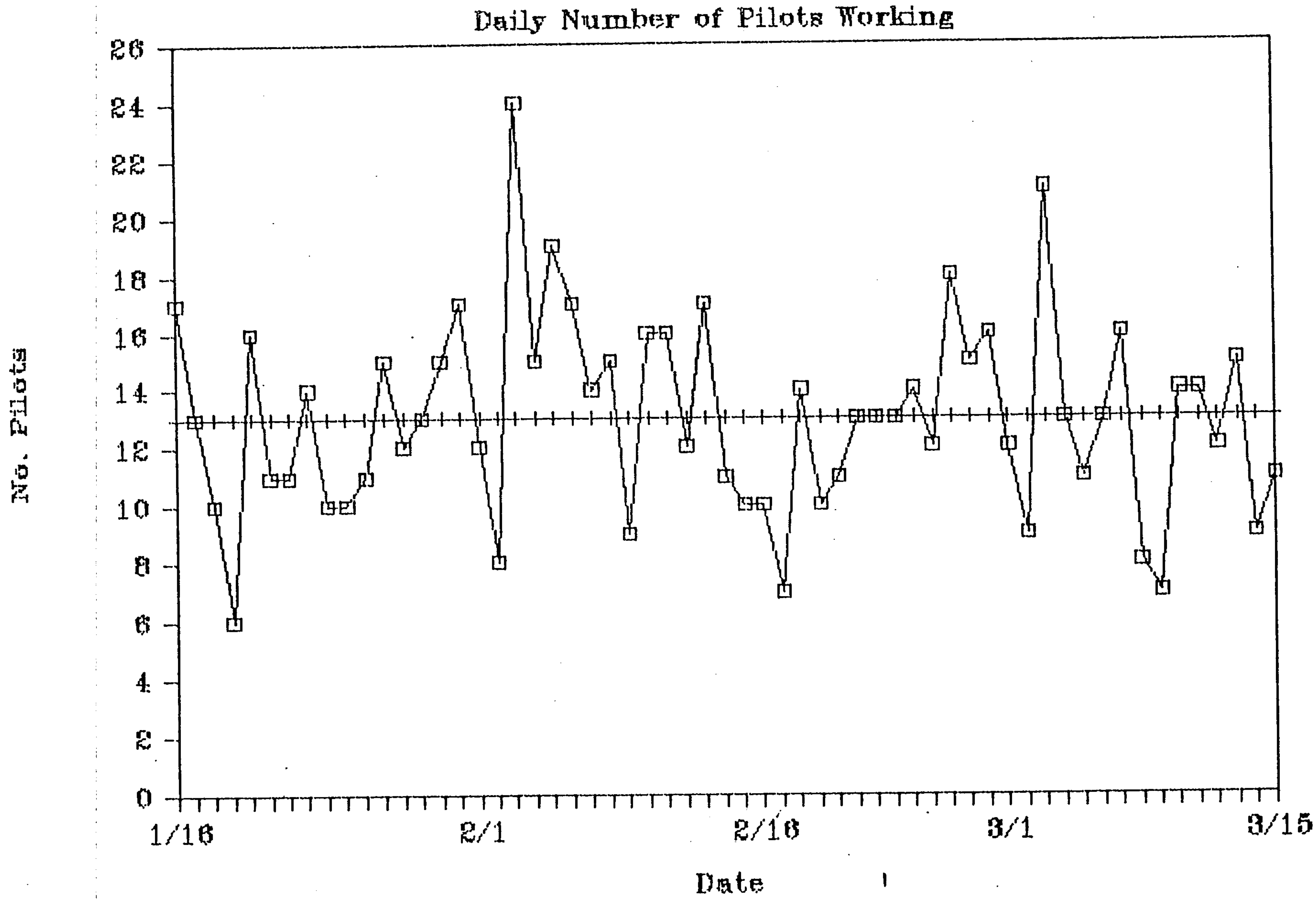
## Pilot Work Rules and Practices

We analyzed three different types of work rules and practices: Minimum Rest Period (time between assignments); Accumulated Time Off (rotation schedule); and other work rules and practices that impact on the number of pilots required.

### Minimum Rest Period

The minimum rest period (MRP) is an important consideration, since reducing the time between assignments is likely not a safe and efficient procedure for accommodating peak demands. A bar pilot spends, on average, 13 to 14 consecutive hours commuting and at work, with only an average 3.5 hour rest period on the station boat to have a quick meal and to relax. To require a pilot to perform consecutive assignments without a proper rest between those assignments could be courting disaster. The simplest, and probably the fairest, method of measuring the MRP is to measure it from the time the pilot leaves the office door homebound, after an assignment, until the time he reports back to the office for his next assignment. An MRP of, say, 12 hours would mean that the average bar pilot would spend 10 hours at home, since the average travel time is one hour each way (Tables 8-10).

Figure 2



Daily Number of Pilots Working
No. Pilots
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1/16
2/1
2/16
3/1
3/15
Date

Accumulated Time Off (ATO)

The pilots are currently on a one-for-one ATO rotation schedule: that is, one day off for one day on. In 1985, the pilots were on a one-for-two ATO rotation schedule: one day off for every two days on. The impact of the switch was to give the pilots more ATO at the cost of less time between assignments. We incorporated the ATO rotation schedule into the Lotus 1-2-3 model through the use of a multiplier:

ATO multiplier = days on + days off divided by days on.

Other Work Rules and Practices

The pilots have only five work rules that limit the amount of time a pilot can spend on assignment:

- Rule 11 that states: "A pilot shall have an inward boarding time of no later than 12 hours after his outward assigned time";

- Rule 51 that states: "When a pilot completes a Stockton/Sacramento pilotage below the SP bridge or a Stockton to or from Sacramento shift (Loop) he shall be compensated by remaining off the board for 8 hours plus 2 hours travel time, after which he goes to the bottom of the board."

- Rule 54 that states: "A pilot assigned to an inbound vessel that is destined north of San Pablo or to Redwood City shall be relieved off the front if on boarding he has been on assignment 8 hours or more";

- Rule 55 that states: "The inside pilot shall work on a watch system of 12 hours on and 12 hours off"; and

- Rule 57 that states: "A pilot assigned to an inbound vessel that is destined north of Port Chicago shall be relieved off the (city) front."

The 12-hour relieve rule (Rule 11) is not called into play during the average day. Table 8 indicates that the pilot has, on average, an inward boarding time of six hours after his outward assigned time. Nor does the rule have an impact on number of pilots required during peak days. During the six peak demand days we analyzed in detail, the demand for pilots was so high that the average time on the station boat was reduced from 3.5 hours to 2.5 hours. In fact, there were no light pilot inbound moves on three of those six peak days. There were light pilot trips to and from the station boat during the peak periods, but the mix of arrivals and sailings were such that they could not be avoided. For example, five pilots made light trips inbound on March 7 at 2100 hours. If those pilots who came in light on March 7 had been required to stay onboard the station boat in order to avoid the five compensating outbound light trips, the station boat time for the total of 16 pilots passing through the station boat before the first replacement pilot arrived would have increased by 18.5 hours, making the total outbound and station boat time an average of 25.5 hours for those 16 pilots due simply to the imbalance between departures and arrivals.

The 8-hour relief rule if a pilot is going north of San Pablo or to Redwood City (Rule 54) does not apply during the average day, since the average time is 6 hours on board the vessel from the station boat; nor does it apply during the peak periods, since the average time aboard the station boat would be even shorter. There were two cases where a pilot was relieved off the waterfront during the peak periods, when neither had exceeded the 8 hour rule. Although we did not determine why these pilots were replaced, we suspect it was because of lack of qualifications in the specific ports the vessel was to be docked or conflict of the pilot's time. In any case, this relief rule does not affect the peak number of pilots.

The Sacramento-Stockton inbound rule (Rule 57) is important because pilots taking a ship from the station to Sacramento or Stockton would be on the bridge for about 10 hours and on total assignment for about 16 hours (counting the average outbound time to the station boat). It would have little effect on the number of pilots during peak periods, mostly because of the limited probability of a ship destined for either port arriving during the peak period.

The extra rest rule after a Stockton-Sacramento run (Rule 51) has an impact on the number of pilots required during the peak periods--but only when the minimum rest period is 12 hours or less. A pilot should be added when the MRP is equal to 12 hours or less and the MRP plus the extra time is greater than 20 hours. For example, if the MRP equals ten hours and the Rule 51 extra rest period was ten hours or more, an extra pilot should be added to the board as both of the above conditions have been met.

We looked at the 12-hour shift rule for the inside pilots (Rule 55) and could not find a reasonable alternative that would reduce the number of pilots required during the peak periods.

To summarize our evaluation of the various work rules and practices: only the MRP, the ATO, and Work Rule 51 have an impact on the number of pilots required during the peak periods.

# IV. "WHAT-IF" MODEL

The number of pilots required to prevent ship delays is a function of the random variability in the day-to-day vessel movements and the pilot work rules. In order to explore the relationships between the ship movements, pilot work rules and number of pilots required, we developed a series of computer models. These analytical models were used to determine the impact of peak demands on pilots and to explore the impact of work rules. The output of these models and the peak demand model formed the relationships incorporated in a straight-forward Lotus 1-2-3 model that would allow the pilots, the industry and the Commission to explore the impact of various rules and assumptions on the number of pilots required.

## Average Number of Pilots Required

Table 11 presents a series of equations that calculates the number of pilots required on average using the average times contained in Tables 8-10. These equations serve as a foundation for the "what-if" computer model developed in this study.

There are two equations for bar moves because, typically, pilots serve more arrivals than sailings. This imbalance between arrivals and sailings is caused by the fact that not all vessels require a pilot (naval vessels, for example). On those occasions when the use of a pilot is at the master's discretion, the arriving master frequently will utilize a bar pilot because of the uncertainty in arrival and difficulty in docking but will take the ship out without a pilot. The first equation under bar moves determines the maximum number of two-way moves (i.e., a move where a pilot will take a ship out and bring a second ship back in). The second equation then determines the minimum number of one-way or light moves.

The term "MRP" in the various equations is the Minimum Rest Period, or the minimum time between assignments--one of the work rules we investigated. The number "2" in the denominator of the bay moves

Table 11

NUMBER ACTIVE PILOTS REQUIRED

Active Pilots (On Board) Required For:

Bar Moves

$$\frac{\text{Minimum (Arrival, Sail)}}{\text{Days in Period}} * \frac{(11.75 + \text{MRP})}{24}$$

$$\frac{\text{Maximum (Arrival, Sail)} - \text{Min. (Arrival, Sail)}}{\text{Days in Period}} * \frac{(10.75 + \text{MRP})}{24}$$

Bay Moves

$$\frac{\text{Number of Bay Moves}}{2 * \text{Days in Period}} * \frac{(13.00 + \text{MRP})}{24}$$

River Moves

$$\frac{\text{Number of River Moves}}{\text{Days in Period}} * \frac{(13.00 + \text{MRP})}{24}$$

Total Active Pilots

equation represents the assumption that a pilot should be able to perform two bay moves per shift.

The major drawback with a model based only on these equations is that it is constructed under the assumption that the ship movements are evenly distributed throughout time so that the number of two-way bar moves are maximized and that two bay moves can be performed in a shift. Unfortunately, ship movements are not so distributed. In fact, ship moves can be described as somewhat erratic.

One alternative procedure that could have been used in this case was to develop a Monte Carlo simulation. In such a simulation, an event, such as a vessel arrival, is characterized by a probability distribution function. Then, during the simulation, a random number is generated and a corresponding number of arrivals is selected from the probability distribution function. This approach requires that the event, such as vessel arrivals, be simulated many, many different times, so that eventually the vessel arrivals over the time period simulated in fact conform to the probability distribution function. This approach also requires that the events be independent: that is, that the arrivals, sailings, bay moves, and river moves are all independent of each other and that there would be, in essence, four different probability distribution functions for these events.

There are two principal reasons why such a Monte Carlo simulation was not employed in this case. First, the arrivals are not truly independent: there is a mechanism which has the impact of keeping the arrivals fairly evenly distributed throughout time: for example, APL's containerships arrive every Friday, and Matson's ships arrive every Wednesday. The probabilities that the APL ships arrive on Thursday or that Matson ships arrive on Friday or that either carrier would have two arrivals within a week are remote. Even a non-liner operation, such as Levin Metals in Richmond, will tend to distribute its scrap iron shipments throughout the year simply because they generate scrap metal more or less continuously through the year and they do not have an infinitely large storage capacity. The second reason for not performing a Monte Carlo simulation is that the two-month study period was not, in our opinion, long enough to develop accurate probability distribution functions, particularly in light of the fact that the arrivals are not truly independent. Accordingly, we elected to evaluate peak-to-average ratios, the impact of work rules, etc. and to assume that these ratios and these impacts as observed during the study period are representative.

## Peak Pilot Demands

A model was developed to determine the peak demands for pilots. These peak demands were then analyzed and adjusted as necessary to eliminate pilots who were on ATO but who came in for administrative duties and pilots who were making training trips. These activities are discretionary and do not contribute to the peak demands for pilots. Although the pilots who were on ATO and came in for administrative duties were eliminated from the peak analysis, there were some pilots who were on the board and still performed administrative duties. We tend to believe that these times were probably not discretionary and therefore in fact contributed to peak demands. Table 12 summarizes the results of this analysis by describing the number of pilots working ships as well as on administrative time (only when the pilots working on administrative duties are on the board).

We analyzed the number of pilots required during six different peak days and developed the average number of pilots required as a function of the different MRP values utilizing the average time relationships presented in Table 11. Note that February 5 is the highest peak day in all cases except when the minimum rest period is 18 hours; February 5 is the day with 20 ship arrivals as shown in Figure 1. As the minimum rest period is increased, more and more pilots cannot meet their commitments because they cannot return and accept another assignment as frequently as they could with a lower MRP value. Accordingly, additional pilots are required. The number of pilots shown in Table 12 does not include Captain Meyer, the Port Agent, who is a full-time administrator.

Table 12

PEAK DAY ANALYSIS

| | | Number Pilots "On the Board" Peak Day | | | | | |
|---|---|---|---|---|---|---|---|
| | Avg. | 1/31 | 2/3 | 2/4 | 2/5 | 2/10 | 3/7 |
| MRP = 8 | | | | | | | |
| No. Pilots Working Ships | | 19 | 18 | | 23 | 19 | |
| No. Pilots on Admin. Time | | 2 | 3 | | -- | 1 | |
| Total | 10.3 | 21 | 21 | | 23 | 20 | |
| MRP = 10 | | | | | | | |
| No. Pilots Working Ships | | 20 | 20 | | 25 | 22 | |
| No. Pilots on Admin. Time | | 2 | 3 | | 1 | 1 | |
| Total | 11.4 | 22 | 23 | | 26 | 23 | |
| MRP = 12 | | | | | | | |
| No. Pilots Working Ships | | | 20 | 17 | 27 | 22 | |
| No. Pilots on Admin. Time | | | 3 | 3 | 1 | 1 | |
| Total | 12.4 | | 23 | 20 | 28 | 23 | |
| MRP = 14 | | | | | | | |
| No. Pilots Working Ships | | | 21 | | 29 | 23 | 26 |
| No. Pilots on Admin. Time | | | 3 | | 1 | 1 | 2 |
| Total | 13.4 | | 24 | | 30 | 24 | 28 |
| MRP = 16 | | | | | | | |
| No. Pilots Working Ships | | | 23 | | 31 | 24 | 27 |
| No. Pilots on Admin. Time | | | 3 | | 1 | 1 | 2 |
| Total | 14.4 | | 26 | | 32 | 25 | 29 |
| MRP = 18 | | | | | | | |
| No. Pilots Working Ships | | | 23 | | 31 | 25 | 31 |
| No. Pilots on Admin. Time | | | 3 | | 1 | 1 | 3 |
| Total | 15.5 | | 26 | | 32 | 26 | 34 |

Impact of pilot shortfall

The basic question facing the pilots, the industry, and the Commission is: Should there be enough pilots on the board to cover the peaks? There are other alternatives: the minimum rest period could be violated during the peak periods, if the remaining portion of the rest period of the affected pilots were still of reasonable length, or pilots could be called in from ATO to cover those peaks.

If one of these alternatives is chosen, the question then becomes: What should the difference be between the number of pilots on the board and the peak demands? To provide some guidance to the pilots, the industry and the Commission as to the differences or the impact of the differences, we developed Table 13.

Table 13 presents the peak number of pilots required as a function of the MRP (from Table 12). In addition, it presents what would happen if the number of pilots on the board were one, two, and three less than the peak required, in terms of the additional pilots required per month, the average reduction in the MRP, and the maximum reduction in the MRP. Consider, for example, the case where the MRP is only eight hours and the peak demand for pilots is 23 pilots.

If only 22 pilots were available, on the average of once every other month some action would have to be taken to increase the effective number of pilots on the board to avoid ship delays. Either one pilot would have to be brought in from ATO or one pilot on the board would have to accept an assignment even though the eight hour MRP were violated. This violation would amount to a reduction of 1.75 hours from his MRP, and the pilot's total rest period, including commute time to and from the office, would then be only 6.25 hours.

If only 21 pilots were available, on the average of once every month some action would have to be taken to cover peak activities. Either two pilots on the board would have to be brought from ATO or two pilots would have to accept assignments with less than the minimum MRP

Table 13

IMPACT OF PILOT SHORTFALL

| | MRP | | | | | |
|---|---|---|---|---|---|---|
| | 8 | 10 | 12 | 14 | 16 | 18 |
| Peak Pilots Required | 23 | 26 | 28 | 30 | 32 | 34 |
| | | | | | | |
| No. Pilots Available | 22 | 25 | 27 | 29 | 31 | 33 |
| No. Times 1 Add'l. Pilot Required/Month | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Avg. Reduction in MRP (hrs) | 1.75 | 0.75 | 2.75 | 4.75 | 6.75 | 3.50 |
| Maximum Reduction in MRP (hrs) | 1.75 | 0.75 | 2.75 | 4.75 | 6.75 | 3.50 |
| | | | | | | |
| No. Pilots Available | 21 | 24 | 26 | 28 | 30 | 32 |
| No. Times 2 Add'l. Pilots Required/Month | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Avg. Reduction in MRP (hrs) | 2.75 | 3.25 | 5.25 | 7.25 | 7.25 | 5.25 |
| Maximum Reduction in MRP (hrs) | 4.00 | 5.50 | 7.50 | 9.50 | 11.50 | 6.75 |
| | | | | | | |
| No. Pilots Available | 20 | 23 | 25 | 27 | 29 | 31 |
| No. Times 3 Add'l. Pilots Required/Month | 2.5 | 1.5 | 1.5 | 2.0 | 1.5 | 2.5 |
| Avg. Reduction in MRP (hrs) | 4.25 | 4.00 | 6.00 | 6.50 | 10.00 | 4.75 |
| Maximum Reduction in MRP (hrs) | 6.00 | 6.00 | 8.00 | 10.00 | 12.00 | 8.00 |

of 8 hours. On average, these two pilots would have a rest period of 5¼ hours and one of them would have a rest period of only 4 hours.

If only 20 pilots were available, on the average of 2.25 times per month three pilots would have to be called in or three pilots on the board would have an average MRP of 3.75 hours and one would have an MRP of only 2.0 hours.

Overall, it appears that it might be safe and feasible to "short-turn" a pilot when the deficiency is only one pilot. The minimum rest period for that one pilot would range from at least six hours (MRP equal to eight) to 9.25 hours or more (MRP greater than ten). If two or more pilots were required, however, the minimum rest period for all but the first of those pilots would drop to less than five hours, which does not seem to be an appropriate alternative. Accordingly, under those cases where two or more pilots are required, only one pilot should be a short-turn pilot. The other pilots should be called in from ATO.

Peak multipliers

Table 14 presents the peak multipliers as a function of: 1) the MRP; 2) the number of pilots required; and 3) the difference between the number of pilots required for the peak conditions versus the number of pilots on the board. Overall, analysis of the sample period indicated that the number of pilots required to cover the peak conditions is approximately 2.25 times the average number of pilots required. And, if the number of pilots on the board is one less than the peak number required, the average multiplier drops to 2.16; the multiplier drops to 2.08 if there were two pilots less and to 2.00 if there were three pilots less.

Seasonality is another multiplier that needs to be considered. Not only will there have to be enough pilots to meet the peak demands as indicated by our analysis of the sample period movements during January, February, and March, but there will have to be enough pilots to meet peak daily demand during the seasonal peaks in traffic volume.

Table 14

PEAK MULTIPLIERS

| Minimum Rest Period | 8 | 10 | 12 | 14 | 16 | 18 | Avg. |
|---|---|---|---|---|---|---|---|
| Average Pilots Required | 10.3 | 11.4 | 12.4 | 13.4 | 14.5 | 15.5 | |
| Peak Pilots Required | 23 | 26 | 28 | 30 | 32 | 34 | |
| Multipliers | 2.23 | 2.28 | 2.26 | 2.24 | 2.21 | 2.19 | 2.24 |
| If 1 Pilot Short | 22 | 25 | 27 | 29 | 31 | 33 | |
| Then Multipliers Would Be: | 2.14 | 2.19 | 2.18 | 2.16 | 2.14 | 2.13 | 2.16 |
| If 2 Pilots Short | 21 | 24 | 26 | 28 | 30 | 32 | |
| Then Multipliers Would Be: | 2.04 | 2.11 | 2.10 | 2.09 | 2.07 | 2.06 | 2.08 |
| If 3 Pilots Short | 20 | 23 | 25 | 27 | 29 | 31 | |
| Then Multipliers Would Be: | 1.94 | 2.02 | 2.02 | 2.01 | 2.00 | 2.00 | 2.00 |

Table 15 presents the average number of bar moves per day for the various months. This table is based on the last six years of vessel traffic (1980-1985). February is the lightest month and June is the heaviest month--11 percent higher than February. Included in the table is a seasonal factor that will have to be applied to any specific month to determine the number of pilots required in the peak month of June. For example, the number of pilots required in January would have to be increased by 9 percent in order to have a sufficient number of pilots available in June to cover increased bar and corresponding bay moves.

"What-If" Model Structure

Table 16 summarizes the six steps in the "what-if" model structure. The structure itself is based on Lotus 1-2-3 spread sheet software. The first model step is to determine the average number of pilots required using the relationships presented in Table 11. This number then is multiplied by the peak multiplier to account for the fact that the number of pilots required to accommodate the peak demands in any given month is 2.25 times higher than the average. The resulting number, in turn, is multiplied to account for variations in demand (ship activity) by month. In addition, the number of pilots required is multiplied by a sick leave factor and by an ATO ratio. Finally, an allowance is added for administrative time.

During the sample period, sick leave amounted to 4.19 percent of duty time. This amount is comparable to sick leave allowance of two weeks per year usually accorded to people who work 40 hours per week: two weeks sick leave for 50 weeks "duty time" is equivalent to 4 percent. The 4.19 percent would have been lower--approximately 2.4 percent--had it not been for one pilot who was on sick leave nearly the entire sample period. Accordingly, the sample period results cannot be considered to be out of line, especially given the fact that January, February, and March is high "sick season." We are not sure what a reasonable sickleave factor should be for pilots, but we think it should be near to the sickleave standard of 4.0 percent.

Table 15

SEASONAL FACTOR

| Month | Bar Moves Per Day | Seasonality Factor |
|---|---|---|
| January | 18.84 | 1.09 |
| February | 18.47 | 1.11 |
| March | 19.27 | 1.07 |
| April | 19.33 | 1.06 |
| May | 19.67 | 1.04 |
| June | 20.53 | 1.00 |
| July | 20.05 | 1.02 |
| August | 19.94 | 1.03 |
| September | 19.77 | 1.04 |
| October | 19.27 | 1.07 |
| November | 19.41 | 1.06 |
| December | 18.81 | 1.09 |
| Average | 19.45 | 1.06 |

Table 16

LOTUS MODEL STRUCTURE

1) Calculate Average Number of Active Pilots Required (from Table 11)

2) Multiply by Peak Multiplier

3) Multiply by Seasonal Factor

4) Multiply by Sick Leave Factor

5) Multiply by an ATO Ratio

6) Add an Administrative Time Allowance

Insofar as administrative time is concerned, one pilot has to be added to account for the Port Agent. Additional pilots have to be added to take into consideration the demands for other types of administrative time. During the sample period, an average of 2.43 pilots were engaged in administrative efforts in addition to the Port Agent. We developed this number by accumulating all pilot time spent on administrative duties (assuming a maximum of 40 hours per week per pilot) during the sample period. That number includes two trips to the East Coast by Captain Charlesworth and Captain Waugh as well as other extraordinary pilot administrative efforts relating to the pilotage rate hearing that commenced near the end of the survey period. We do not have any idea of what a good allowance for administrative time should be. The model will accommodate any number for administrative time (as it can for ten other "what-if" variables).

"What-If" Model Operation

Table 17 presents the input/output section of the Lotus 1-2-3 model.

Model Input

The Starting Date is simply a reference header. In fact, it can be any descriptor the user desires (including, but not restricted to, a date). Following the starting date are the following 11 required input items:

1) number of days in the period

2) number of arrivals;

3) number of sailings;

4) number of bay moves;

5) number of river moves;

6) Minimum Rest Period (MRP) in hours;

TABLE 17: PILOT MANNING MODEL

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT the starting date or descriptor... | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 | 1/16/86 |
| INPUT the number of days in the period... | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 59 |
| INPUT the number of Arrivals ... | 549 | 549 | 549 | 549 | 549 | 549 | 549 | 549 | 549 | 549 | 549 |
| INPUT the number of Sailings ... | 536 | 536 | 536 | 536 | 536 | 536 | 536 | 536 | 536 | 536 | 536 |
| INPUT the number of Bay Moves ... | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 |
| INPUT the number of River Moves ... | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| INPUT the MRP ... | 10 | 10 | 10 | 10 | 12 | 12 | 12 | 12 | 14 | 16 | 18 |
| INPUT Rule 51 extra hours ... | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| INPUT seasonal factor ... | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 |
| INPUT sick leave factor (%) ... | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 | 4.19 |
| INPUT the ATO ratio ... | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| INPUT administrative factor (No. men) ... | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 | 3.43 |
| Total pilots required for peaks... ======== === ===== | 63 | 63 | 63 | 63 | 71 | 71 | 71 | 71 | 74 | 79 | 85 |
| INPUT the number of pilots desired ... | 61 | 59 | 57 | 55 | 69 | 67 | 65 | 63 | | | |
| Average no. times (per year) not enough pilots on the board.. | 1.5 | 6.0 | 13.5 | 27.0 | 1.5 | 5.0 | 12.0 | 24.5 | 0.0 | 0.0 | 0.0 |
| Average no. of pilots called in from ATO or with reduced MRP (per year) ... | 1.5 | 9.0 | 31.5 | 90.0 | 1.5 | 8.0 | 28.0 | 80.5 | 0.0 | 0.0 | 0.0 |
| Maximum no. of pilots called in from ATO in any given month ... | 1 | 2 | 6 | 16 | 1 | 2 | 6 | 16 | 0 | 0 | 0 |

TABLE 17: PILOT MANNING MODEL

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pilots required for two-way Bar Moves ... | 20.6 | 20.6 | 20.6 | 20.6 | 22.5 | 22.5 | 22.5 | 22.5 | 24.3 | 26.2 | 28.1 |
| Pilots required for one-way Bar Moves ... | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 |
| Pilots required for Bay Moves ... | 5.9 | 5.9 | 5.9 | 5.9 | 6.4 | 6.4 | 6.4 | 6.4 | 6.9 | 7.4 | 7.9 |
| Pilots required for River Moves ... | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 | 1.6 | 1.6 | 1.6 | 1.8 | 1.9 | 2.0 |
| Pilots required for Rule 51 ... | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.1 | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 |
| Pilots on sick leave ... | 1.2 | 1.2 | 1.2 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.4 | 1.5 | 1.6 |
| Total pilots req'd "On the Board" ... | 29.6 | 29.6 | 29.6 | 29.6 | 33.5 | 33.5 | 33.5 | 33.5 | 35.0 | 37.7 | 40.4 |
| Total pilots desired "On the Board" ... | 28.6 | 27.6 | 26.6 | 25.6 | 32.5 | 31.5 | 30.5 | 29.5 | 35.0 | 37.7 | 40.4 |
| Total pilots req'd "On the Board" each month adjusted by the following Seasonality Factors | | | | | | | | | | | |
| January 1.09 | 27.2 | 27.2 | 27.2 | 27.2 | 30.7 | 30.7 | 30.7 | 30.7 | 32.1 | 34.6 | 37.0 |
| February 1.11 | 26.7 | 26.7 | 26.7 | 26.7 | 30.1 | 30.1 | 30.1 | 30.1 | 31.5 | 33.9 | 36.4 |
| March 1.07 | 27.7 | 27.7 | 27.7 | 27.7 | 31.3 | 31.3 | 31.3 | 31.3 | 32.7 | 35.2 | 37.7 |
| April 1.06 | 27.9 | 27.9 | 27.9 | 27.9 | 31.6 | 31.6 | 31.6 | 31.6 | 33.0 | 35.5 | 38.1 |
| May 1.04 | 28.5 | 28.5 | 28.5 | 28.5 | 32.2 | 32.2 | 32.2 | 32.2 | 33.6 | 36.2 | 38.8 |
| June 1.00 | 29.6 | 29.6 | 29.6 | 29.6 | 33.5 | 33.5 | 33.5 | 33.5 | 35.0 | 37.7 | 40.4 |
| July 1.02 | 29.0 | 29.0 | 29.0 | 29.0 | 32.8 | 32.8 | 32.8 | 32.8 | 34.3 | 36.9 | 39.6 |
| August 1.03 | 28.7 | 28.7 | 28.7 | 28.7 | 32.5 | 32.5 | 32.5 | 32.5 | 34.0 | 36.6 | 39.2 |
| September 1.04 | 28.5 | 28.5 | 28.5 | 28.5 | 32.2 | 32.2 | 32.2 | 32.2 | 33.6 | 36.2 | 38.8 |
| October 1.07 | 27.7 | 27.7 | 27.7 | 27.7 | 31.3 | 31.3 | 31.3 | 31.3 | 32.7 | 35.2 | 37.7 |
| November 1.06 | 27.9 | 27.9 | 27.9 | 27.9 | 31.6 | 31.6 | 31.6 | 31.6 | 33.0 | 35.5 | 38.1 |
| December 1.09 | 27.2 | 27.2 | 27.2 | 27.2 | 30.7 | 30.7 | 30.7 | 30.7 | 32.1 | 34.6 | 37.0 |
| No. times will have to call in extra pilots-- either with reduced MRP or from ATO | | | | | | | | | | | |
| January | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 |
| February | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 |
| March | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 |
| April | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| May | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| June | 0.5 | 1.0 | 2.0 | 4.0 | 0.5 | 1.0 | 2.0 | 4.0 | 0.0 | 0.0 | 0.0 |

TABLE 17: PILOT MANNING MODEL

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July | 0.5 | 1.0 | 2.0 | 4.0 | 0.5 | 1.0 | 2.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| August | 0.5 | 1.0 | 2.0 | 4.0 | 0.5 | 1.0 | 2.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| September | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 |
| November | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.5 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| December | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 |
| total | 1.5 | 6.0 | 13.5 | 27.0 | 1.5 | 5.0 | 12.0 | 24.5 | 0.0 | 0.0 | 0.0 |
| **No. extra pilots needed, when extra pilots are called** | | | | | | | | | | | |
| January | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| February | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| March | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| April | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 0.0 |
| May | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 0.0 |
| June | 1.0 | 2.0 | 3.0 | 4.0 | 1.0 | 2.0 | 3.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| July | 1.0 | 2.0 | 3.0 | 4.0 | 1.0 | 2.0 | 3.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| August | 1.0 | 2.0 | 3.0 | 4.0 | 1.0 | 2.0 | 3.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| September | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| November | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 | 0.0 | 0.0 |
| December | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| **Average number of pilots called in** | | | | | | | | | | | |
| January | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 |
| February | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 |
| March | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 |
| April | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.0 |
| May | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.0 |
| June | 0.5 | 2.0 | 6.0 | 16.0 | 0.5 | 2.0 | 6.0 | 16.0 | 0.0 | 0.0 | 0.0 |
| July | 0.5 | 2.0 | 6.0 | 16.0 | 0.5 | 2.0 | 6.0 | 16.0 | 0.0 | 0.0 | 0.0 |
| August | 0.5 | 2.0 | 6.0 | 16.0 | 0.5 | 2.0 | 6.0 | 16.0 | 0.0 | 0.0 | 0.0 |
| September | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 |
| November | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.5 | 2.0 | 6.0 | 0.0 | 0.0 | 0.0 |
| December | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 |
| total | 1.5 | 9.0 | 31.5 | 90.0 | 1.5 | 8.0 | 28.0 | 80.5 | 0.0 | 0.0 | 0.0 |
| maximum | 0.5 | 2.0 | 6.0 | 16.0 | 0.5 | 2.0 | 6.0 | 16.0 | 0.0 | 0.0 | 0.0 |
| INPUT peak multiplier ... | 2.25 | | | | | | | | | | |

7) Rule 51 extra time (only where applicable);

8) seasonal multiplier factor;

9) sick leave multiplier factor;

10) ATO ratio; and

11) administration factor.

Model output

The model calculates the total number of pilots required to cover all the annual peaks in pilot demand, assuming a peaking factor of 2.25. Immediately below this calculated number of pilots there is another input parameter: the desired number of pilots. This parameter allows the model operator to inquire, from the model, the impact of having less than the calculated number of pilots to handle the peak demand. The subsequent output based on the desired number of pilots, then, indicates:

1) the number of times during the year when there were not enough pilots on the board;

2) the number of pilots that would have to be called in to supplement the pilots on the board (either by having pilots take an assignment with less than the MRP or by calling pilots in from ATO); and

3) the maximum number of pilots--in any given month--that must be called in to supplement the pilots on board (or accept reduced MRP) under the conditions specified by the 11 input parameters.

In the Table 17 examples, the number of days in the period, the number of arrivals and sailings, and the bay moves and river moves happen to be those experienced during the sample period. These input parameters can be modified to reflect current or forecasted traffic volumes. The samples in Table 17 contains 11 different scenarios: four scenarios with an MRP of 10 hours, four with an MRP of 12 hours, and one each with the MRP set at 14, 16, and 18 hours. The Rule 51--extra time following a river move--is set at the current ten hours. The seasonal factor is 11 percent in all runs, reflecting the seasonal factor for February (the difference between that sample month traffic volumes and the historical peak traffic volumes in June). The sick leave and ATO factors of 4.19 and 2.0, respectively, are those that were in effect during the study period. And we have allowed the equivalent of 3.43 men on administrative activities (2.43 plus the Port Agent).

Sample Results

An example from Table 17 shows that if the MRP were set at 10 hours, a total of 63 pilots would be required in order to have a sufficient number of pilots to accommodate the annual peak demand. If the desired number of pilots were set to 61 pilots, some sort of action to supplement pilots on the Board would have to be taken on the average 1.5 times per year. This action could consist of either short-turning a pilot or calling a pilot in from ATO. If short-turning a pilot were not a desirable option, then on average, 1.5 pilots would be called in each year. In this particular example--where the ATO ratio is two--the two-pilot difference between 63 and 61 pilots represents only a one-pilot difference insofar as the number of pilots on the board are concerned.

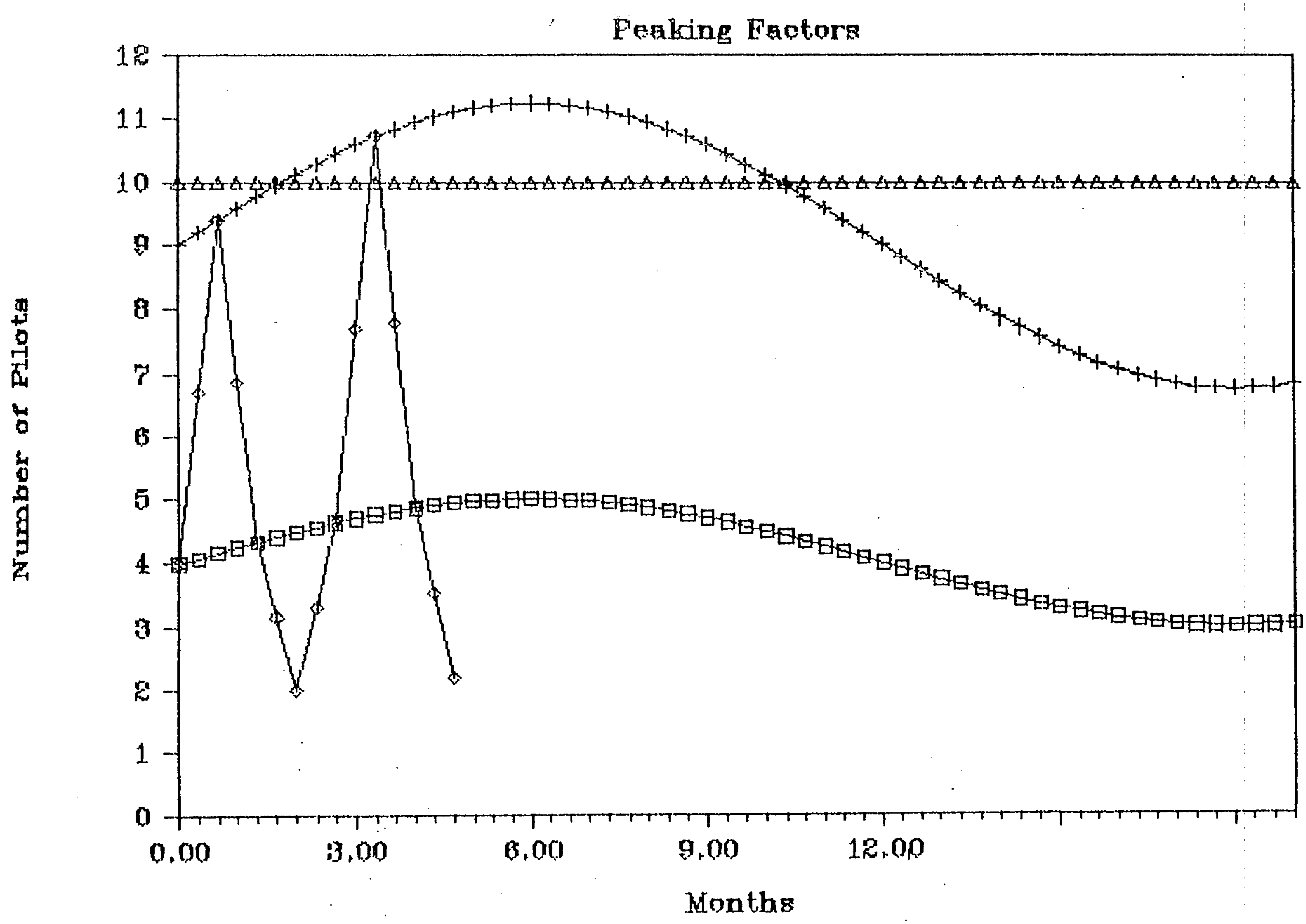
There appears to be enough flexibility in the pilot rotation system to accommodate the case where the number of pilots on the board is one less than the calculated number of pilots required to accommodate annual peak demand. Because of the infrequency of single pilot shortage, and because calling in one pilot either from ATO or by slightly reducing another's minimum rest period is not particularly onerous, it is probably not a serious threat to safe and efficient pilotage. As the number of pilots on the board continues to drop below the calculated number of pilots required to accommodate peak demand, however, it becomes more and more difficult to accommodate the shortage safely. Consider, for example, the second scenario in Table 17, where 63 pilots are required for the peaks and only 59 pilots are desired. The difference of 4 total pilots equates to a difference of 2 pilots on the board because of the ATO ratio of 2.0 (one-for-one rotation). In this example, a shortage will occur six times per year, and nine pilots will be affected (an average of 1.5 pilots per occasion). The worst month will see two pilots affected. This disruption probably could be accommodated as well, since the frequency of occurrence is not high. In those cases where two pilots are required simultaneously to supplement the board, however, we would recommend that only one be short-turned and the other be called in from ATO: to short-turn the second pilot would reduce his actual rest period below acceptable levels.

If only 57 pilots were desired (the third column of data), pilot supplementary action would have to be taken a little over once a month and, overall, 31½ pilots would be affected by this action. During the peak month, a total of six pilots would have to be called in and, considering the fact that the difference between 63 and 57 pilots is equivalent to three pilots on the board at any one time, 3 pilots would have to be called in on the worst day. This frequency and the number of pilots affected probably represent an unacceptable situation; peak day demand cannot be forecast, and it is unlikely that three pilots can be conveniently found in a very short period of time.

Dropping the number of pilots to 55--the equivalent of a four-pilot shortage on the board at any given time--will cause a serious disruption in the the normal pilot activities. The number of times supplementary pilots will be required will increase to a little more than two times per month, and overall 90 pilots will be affected. During the peak month, a total of 16 pilots would be required to supplement the board, and four additional pilots would be required during the peak day.

Figure 3 illustrates the principles of peaking and the number of pilots required to cover those peaks. The curves in Figure 3 are

Figure 3



Peaking Factors
Number of Pilots
Months
0
1
2
3
4
5
6
7
8
9
10
11
12
0.00
3.00
6.00
9.00
12.00

representative and are not based on any actual values developed as a result of this study. There are four curves shown in the figure. The lowest curve that extends across the figure represent the daily average number of pilots required. This daily average varies slightly from day to day, representing the changing seasonal demand in pilots. The diamond curve that extends only a quarter of the way across the figure represents the day-to-day variations in the demand for pilots. This daily peak number is approximately twice the average. The curve marked by the crosses represents the peak number of pilots required in any particular month. Once again, this curve varies slightly from month to month because of the seasonal variations. Our analysis covered only two months of the year, and we found that the peak number of pilots required is 2.25 times the average number. This number is used in our examples, but it could be any number the model user wishes to use.

The straight diamond horizontal line represents the number of pilots available and on the board. This number is somewhat less than the peak number required during the high season, but more than adequate during the balance of the year. If the number of pilots on the board is four less than the number required, there will be one day during the peak month where, by definition, four additional pilots will be required. There will be additional days in the peak month and in the months on either side of the peak where three pilots will be required, two pilots required, one pilot required, etc. Should the number of pilots on the board drop too low, there will be shortages in every month of the year. And the shortages during the peak month will probably become debilitating. The object, of course, is to strike a balance between keeping the number of pilots at a minimum in order to keep costs at a minimum while at the same time having a sufficient number of pilots on the board so that all vessels, including those during peak periods, can be piloted promptly into and out of the bay by a rested, qualified pilot.

Model Application

The "what-if" model is a straight-forward, yet powerful, computer program that has long-term applicability. Its sophistication is in its design, not in its use. It requires no modification to accommodate future changes in traffic volume or in pilot work rules or practices; only its input parameters need be changed.

The basic design of the model is a spreadsheet; the construction utilizes Lotus "1-2-3" or Lotus "Symphony" software, operating under the IBM PC DOS (version 2.1) Operating System. It will run on an IBM or IBM-compatible personal computer with at least 256K bytes of memory. The model is self-explanatory to an operator familiar with electronic spreadsheet applications. In addition, Manalytics' staff is available to train and assist PMSA or pilot personnel in application of the model.

Because of the importance of the peak multiplier to the generation of pilot demand by the model, the pilots and the industry should establish a method to derive the appropriate value. Statistics should be incorporated in the pilots' day-to-day data collection and invoicing system and periodically reviewed to determine if the peak multiplier in the model should be changed. The two-month sample period in our study is too short; a full year would be best.

One statistic that could be used to monitor the peak multiplier is the duration of the Minimum Rest Period (MRP). If the rest period were to drop below some minimal level, more pilots would be added to the roster. If this is the statistic to be collected, the questions are: How is it collected? What type of program should be used to retrieve and analyze the data? How frequently should the data be analyzed? etc.

The logical data collection system to analyze the level of pilot workload and the peak demand for pilots already exists, at least in large part. An expansion of the pilot invoicing system to account, by individual pilot, for the time of day and duration of specific piloting assignments would provide the necessary data to develop statistics on average daily arrivals, daily and monthly peak demands, and length of the average and minimum rest periods. These statistics would allow for the continuous monitoring of the input variables to the model. At the end of a year's data collection, the model assumptions regarding the peak multiplier as well as the seasonal factor could be verified. We encourage the pilots to expand the current billing system to collect and report these very important statistics as soon as possible and, with PMSA, to use them in the model.

# Appendix A

# BIBLIOGRAPHY

# BIBLIOGRAPHY

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# Appendix B

# COVER LETTER, QUESTIONNAIRES, AND INSTRUCTIONS

**DONALD L. TASTO, PH.D.**
Psychologist
A Professional Corporation

701 Welch Road, Suite 213, Palo Alto, California 94304, (415) 326-0455

February 7, 1986

Dear Bar Pilots:

Enclosed are three separate questionnaires, the Work Environment Scale, the Job Stress Questionnaire, and the San Francisco Bar Pilots Questionnaire.

These questionnaires are to be filled out by each pilot as part of the Pilot Manning Study conducted for the pilots and the Pacific Merchant's Shipping Association by Manalytics, Inc. and Donald L. Tasto, Ph.D.

There are a set of instructions, but if you should have any questions, please feel free to call me at (415) 326-0455.

As noted in the instruction sheet, please try to mail back your completed questionnaires within 24 hours of receiving them.

Sincerely,

Donald L Tasto

Donald L. Tasto, Ph.D.

To: San Francisco Bar Pilots
From: Donald L. Tasto, Ph.D.
Re: Questionnaires
Date: February 7, 1986

# INSTRUCTIONS

**Please read all of these instructions before beginning.**

The Work Environment Scale is a standard published test with statistical norms for assessing individuals perceptions of their working environment. The Job Stress Questionnaire has been used in many research projects to assess degree of perceived stress in one's job; and the Bar Pilots Questionnaire has been developed specifically to obtain more detailed information regarding the precise nature of your work as a bar pilot.

Please keep in mind that the first two questionnaires (i.e. the Work Environment Scale and the Job Stress Questionnaire) have general items, most of which people are able to rate as they apply to their working environment. Not each item on these standardized questionnaires is relevent to the job of a bar pilot. Even though this is the case, please try to interpret each one of the items as it applies to your circumstances and provide an answer as best you can to each one of the items. Failure to answer a significant number of items will cause difficulties in interpreting your scores relative to statistical norms.

Each item on the San Francisco Bar Pilots Questionnaire should be relevent to your job and answerable. Please make sure that all items are answered on this questionnaire.

In answering the questions, please use a **PENCIL** (it does not matter what type) so that you may erase any answers should you change your mind. This will facilitate our own tabulating and scoring procedures.

The success of this project depends upon everyone cooperating and answering these three questionnaires in a timely fashion. It is also most important that you do not collaborate with other pilots but, rather, provide your own answers which represent your true feelings, attitudes, and opinions. Please do not try to exaggerate responses in one direction or another as this will tend to invalidate the test results.

Regarding **confidentiality**, all responses will be held in the strictist of confidence. All information shall be presented in statistical, summary, or conclusion form without reference to any specific individual's responses.

When you complete the questionnaires, please put all materials into the envelope provided and mail back to my office. Since timing is of utmost importance, I would request that you complete your questionnaire and have it in the mail back to me within 24 hours of receiving it.

Again, please be honest, straight forward and timely in your responses so as to assure a most solid base of information from which to draw conclusions.

WORK ENVIRONMENT SCALE

PAUL M. INSEL & RUDOLF H. MOOS

## DIRECTIONS

Look at your test booklet and check the Form printed on it here:

Form R____ E____ I____

Please provide the information requested below.

Your Name ______________________ Age ________

Name of Organization ______________________ Sex: M F (circle)

Department ____________ Job Title ____________

How long have you been with this organization? ________ years ________ months

How long have you been in this department? ________ years ________ months

Today's Date ____________ Other ____________

Now, please read each statement in your booklet and then, in the boxes on the other side of this sheet, mark T (true) if you think the statement is true of your work environment, and F (false) if the statement is not true of your work environment.

EXAMPLE ONLY

| T/F | 1 | 2 |
|---|---|---|
| T | X | |
| F | | X |

Use a heavy X, as in the example: Please use a pencil with an eraser, not a pen. Be sure to match each number in the booklet with each one on this sheet.



START HERE

| T/F | | | | | | | | | | | T/F |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T / F | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | T / F |
| T / F | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | T / F |
| T / F | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | T / F |
| T / F | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | T / F |
| T / F | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | T / F |
| T / F | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | T / F |
| T / F | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | T / F |
| T / F | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | T / F |
| T / F | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | T / F |

do not mark below this line

| | I | PC | SS | A | TO | WP | C | Ctl | Inn | Com |
|---|---|---|---|---|---|---|---|---|---|---|
| R/S | | | | | | | | | | |
| S/S | | | | | | | | | | |

1. The work is really challenging.
2. People go out of their way to help a new employee feel comfortable.
3. Supervisors tend to talk down to employees.
4. Few employees have any important responsibilities.
5. People pay a lot of attention to getting work done.
6. There is constant pressure to keep working.
7. Things are sometimes pretty disorganized.
8. There's a strict emphasis on following policies and regulations.
9. Doing things in a different way is valued.
10. It sometimes gets too hot.
11. There's not much group spirit.
12. The atmosphere is somewhat impersonal.
13. Supervisors usually compliment an employee who does something well.
14. Employees have a great deal of freedom to do as they like.
15. There's a lot of time wasted because of inefficiencies.
16. There always seems to be an urgency about everything.
17. Activities are well-planned.
18. People can wear wild looking clothing while on the job if they want.
19. New and different ideas are always being tried out.
20. The lighting is extremely good.
21. A lot of people seem to be just putting in time.
22. People take a personal interest in each other.
23. Supervisors tend to discourage criticisms from employees.
24. Employees are encouraged to make their own decisions.
25. Things rarely get "put off till tomorrow."
26. People cannot afford to relax.
27. Rules and regulations are somewhat vague and ambiguous.
28. People are expected to follow set rules in doing their work.
29. This place would be one of the first to try out a new idea.
30. Work space is awfully crowded.
31. People seem to take pride in the organization.
32. Employees rarely do things together after work.
33. Supervisors usually give full credit to ideas contributed by employees.
34. People can use their own initiative to do things.
35. This is a highly efficient, work-oriented place.
36. Nobody works too hard.
37. The responsibilities of supervisors are clearly defined.
38. Supervisors keep a rather close watch on employees.
39. Variety and change are not particularly important.
40. This place has a stylish and modern appearance.
41. People put quite a lot of effort into what they do.
42. People are generally frank about how they feel.
43. Supervisors often criticize employees over minor things.
44. Supervisors encourage employees to rely on themselves when a problem arises.
45. Getting a lot of work done is important to people.
46. There is no time pressure.
47. The details of assigned jobs are generally explained to employees.
48. Rules and regulations are pretty well enforced.
49. The same methods have been used for quite a long time.
50. The place could stand some new interior decorations.
51. Few people ever volunteer.
52. Employees often eat lunch together.
53. Employees generally feel free to ask for a raise.
54. Employees generally do not try to be unique and different.
55. There's an emphasis on "work before play."
56. It is very hard to keep up with your work load.
57. Employees are often confused about exactly what they are supposed to do.
58. Supervisors are always checking on employees and supervise them very closely.
59. New approaches to things are rarely tried.
60. The colors and decorations make the place warm and cheerful to work in.
61. It is quite a lively place.
62. Employees who differ greatly from the others in the organization don't get on well.
63. Supervisors expect far too much from employees.
64. Employees are encouraged to learn things even if they are not directly related to the job.
65. Employees work very hard.
66. You can take it easy and still get your work done.
67. Fringe benefits are fully explained to employees.
68. Supervisors do not often give in to employee pressure.
69. Things tend to stay just about the same.
70. It is rather drafty at times.
71. It's hard to get people to do any extra work.
72. Employees often talk to each other about their personal problems.
73. Employees discuss their personal problems with supervisors.

74. Employees function fairly independently of supervisors.

75. People seem to be quite inefficient.

76. There are always deadlines to be met.

77. Rules and policies are constantly changing.

78. Employees are expected to conform rather strictly to the rules and customs.

79. There is a fresh, novel atmosphere about the place.

80. The furniture is usually well-arranged

81. The work is usually very interesting.

82. Often people make trouble by talking behind others' backs.

83. Supervisors really stand up for their people.

84. Supervisors meet with employees regularly to discuss their future work goals.

85. There's a tendency for people to come to work late.

86. People often have to work overtime to get their work done.

87. Supervisors encourage employees to be neat and orderly.

88. If an employee comes in late, he can make it up by staying late.

89. Things always seem to be changing.

90. The rooms are well ventilated.

# WORK ENVIRONMENT SCALE

## FORM R

PAUL M. INSEL & RUDOLF H. MOOS

## INSTRUCTIONS

There are 90 statements in this booklet. They are statements about the place in which you work. The statements are intended to apply to all work environments. However, some words may not be quite suitable for your work environment. For example, the term supervisor is meant to refer to the boss, manager, department head, or the person or persons to whom an employee reports.

You are to decide which statements are true of your work environment and which are false. Make all your marks on the separate answer sheet.

If you think the statement is *TRUE* or mostly *TRUE* of your work environment, make an X in the box labeled T (true).

If you think the statement is *FALSE* or mostly *FALSE* of your work environment, make an X in the box labeled F (false).

Please be sure to answer every statement.

CONSULTING PSYCHOLOGISTS PRESS, INC.
577 College Ave., Palo Alto, California 94306

JOB STRESS QUESTIONNAIRE

Name ______________________________ Date ______________________________

A. All of us occasionally are bothered by certain pressures or stresses in our work. Here is a list of things that sometimes bother people. Please indicate how often you are (or were) bothered by each of them in your work.

Circle the one number that best describes your job.

| | Not at all | Rarely | Sometimes | Rather Often | Nearly all the time |
|---|---|---|---|---|---|
| 1. Not having enough help or equipment to get the job done well. | 1 | 2 | 3 | 4 | 5 |
| 2. Feeling you have too much responsibility for the work of others. | 1 | 2 | 3 | 4 | 5 |
| 3. Thinking that you will not be able to meet the conflicting demands of various people you work with. | 1 | 2 | 3 | 4 | 5 |
| 4. Having to do or decide things where mistakes could be quite costly. | 1 | 2 | 3 | 4 | 5 |
| 5. Not knowing just what the people you work with expect of you. | 1 | 2 | 3 | 4 | 5 |
| 6. Thinking that the amount of work you have to do may interfere with how well it gets done. | 1 | 2 | 3 | 4 | 5 |
| 7. Feeling that you have to do things on the job that are against your better judgment. | 1 | 2 | 3 | 4 | 5 |
| 8. Feeling that your job tends to interfere with your family life. | 1 | 2 | 3 | 4 | 5 |
| 9. Feeling unable to influence your immediate supervisor's decisions and his actions that affect you. | 1 | 2 | 3 | 4 | 5 |
| 10. Having to deal with or satisfy too many different people. | 1 | 2 | 3 | 4 | 5 |

| | Not at all | Rarely | Some-times | Rather Often | Nearly all the time |
|---|---|---|---|---|---|
| 11. Being asked to work overtime when you don't want to. | 1 | 2 | 3 | 4 | 5 |
| 12. Feeling trapped in a job you don't like but can't change and can't get out of. | 1 | 2 | 3 | 4 | 5 |

B. Jobs vary in how much they require people to work fast and hard. Please indicate how often each of the following statements is true of your job.

Circle one number for each question.

| | Never | Rarely | Some-times | Fairly Often | Very Often |
|---|---|---|---|---|---|
| 1. How often does your job require you to work very fast. | 1 | 2 | 3 | 4 | 5 |
| 2. How often does your job require you to work very hard (physically or mentally). | 1 | 2 | 3 | 4 | 5 |
| 3. How often does your job leave you with little time to get everything done. | 1 | 2 | 3 | 4 | 5 |

4. When you do have to work very fast or very hard, would you say this is mainly because:

(Circle one)

1. You expect a lot from yourself.
2. The company, supervisors, or production schedules, require a lot from you.
3. You have to keep up with the people or machines you work with.
4. I never have to work very fast or very hard.

# S A N   F R A N C I S C O   B A R   P I L O T S

# Q U E S T I O N N A I R E

* POTENTIAL STRESS FACTORS
* SATISFACTION/DISSATISFACTION
* REACTIONS TO THE JOB
* OPEN ENDED QUESTIONS

Developed by: Donald L. Tasto, Ph.D.
&
Manalytics, Inc.

Date: February 1, 1986

# POTENTIAL STRESS FACTORS

Please rate each item on a 10 point scale as to how stressful or non-stressful you find it to be as it applies to <u>you</u>. Place a number from 1 to 10 after each item.

| NON STRESSFUL | | | | | | | | | EXTREMELY STRESSFUL |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

1. Approaching the dock ______
2. Docking a vessel ______
3. Undocking a vessel ______
4. Length of time between assignments ______
5. Attitudes and philosophy of the commission ______
6. Time spent on pilot boat ______
7. Time pressure/time demands ______
8. Language barriers with the crew ______
9. Average number of work hours worked per week ______
10. Sea sickness ______
11. Irregularity or unpredictability in assignment times after the first call from the dispatcher. ______
12. <u>Anticipatory period</u> between dispatcher's call and actual commencement of work assignment. ______
13. Spouses reaction to your work schedule. ______
14. Weather conditions (fog, visibility, rain, wind, rough seas, etc.) ______
15. Differences from one crew to the next ______
16. Differences in vessel characteristics ______
17. Boarding a vessel from the pilot boat ______
18. Boarding the pilot boat from a vessel ______
19. Delays (due to weather, changes in arrival or departure times, etc). ______
20. Level of responsibility ______

## SATISFACTION/DISSATISFACTION

The following items have to do with the degree to which you feel satisfied or dissatisfied with various elements related to the job. Please rate each of these items on a 10 point scale, with a number 1 representing high dissatisfaction and a number 10 representing extremely satisfied i.e. the more satisfaction you are with the item, the higher your rating will be.

| EXTREMELY DISSATISFIED | | | | | | | | | EXTREMELY SATISFIED |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

1. Type of work, i.e. nature of the job itself _____
2. Level of support from co-workers _____
3. Financial compensation _____
4. Work hours _____
5. Work load _____
6. Quality of sleep during work periods _____
7. Quality of sleep on the pilot boat _____
8. Quality of sleep between the time you are called by the dispatcher and the time you leave your home _____
9. Quality of sleep during the day time of work periods _____
10. Quality of sleep patterns during ATO _____
11. Eating patterns during work periods _____
12. Length of time between assignments _____
13. The 12 hour rule _____
14. Effects of work schedule on family life _____
15. Effects of work schedule on social life _____

# REACTIONS TO THE JOB

People react to stress and demand in a variety of ways, and such reactions are often best described by the feelings that they have. Listed below are a number of reactions that people may or may not have depending upon the nature of their work and their own personality makeup. Please rate on a 10 point scale how much of a problem you may have with each of the following <u>during work periods</u> (as opposed to ATO or non-work periods.)

| NO PROBLEM | | | | | | | | | SEVERE PROBLEM |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

1. Anxious ______
2. Worried ______
3. Frustrated ______
4. Angry ______
5. Hostile ______
6. Depressed ______
7. Fatigued ______
8. Confused ______
9. Nervous ______
10. Irritable ______
11. Grouchy ______
12. Spaced-out ______
13. Tired ______
14. Groggy ______
15. Apprehensive ______
16. Unable to sleep ______
17. Wound-up ______
18. Moody ______
19. Sluggish ______
20. Tense ______

OPEN ENDED QUESTIONS

The following questions, depending upon how answered, may require a written response. (If you need more room, you can write on the back of these sheets.)

1. Do you feel that in general or an average, there is sufficient time in between assignments?

   Yes_____ No_____

   If no, what would you realistically like to see as the minimum amount of time between assignments?

   ______________________________

2. Do you feel that the compensation for your work is adequate? Yes_____ No_____

   If no, how much would be reasonably adequate?

   ______________________________

3. If you had to chose between (A) an increase in compensation and (B) more time between assignments, which would you choose? A_____ B_____

4. What do you feel (please be realistic, of course) the ideal number of bar pilots would be?

   ______________________________

Do you have any specific problems associated with your work as a bar pilot that have not been covered with the above questions? If so, please use space below to describe them.

______________________________

______________________________

______________________________

______________________________

Are there any changes that you feel are necessary to make the job more reasonable? If so please list below.

______________________________

______________________________

______________________________

______________________________